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Edited by

LEWIS STEPHEN PILCHER, M.D., LL.D.

of New York

With the Collaboration of

SIR WILLIAM MACEWEN, M.D., LL.D.

of Glasgow

SIR W. WATSON CHEYNE, C.B., F.R.S.

of London

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THE INFLUENCE OF THE WAR UPON THE DEVELOPMENT OF SURGERY*

BY JOSEPH A. BLAKE, M.D.
OF NEW YORK

DIRECTOR OF THE AMERICAN RED CROSS HOSPITAL, NO. 2, PARIS, FRANCE

It has been my great privilege to work side by side with the surgeons and physicians of France throughout the period of the war, and I could ask for no greater honor than that you have accorded me in inviting me to speak to you to-day. This honor I accept, not wholly for myself, but also as a tribute to my fellow American surgeons.

I must confess to a feeling of disappointment in regard to the influence the experience derived from the observation and treatment of wounds during the war has had upon the development of surgical science. There has been little of new in the knowledge we have obtained. There has rather been a confirmation of principles already known, and the progress that has been achieved has been principally in stabilizing treatment rather than in making discoveries. I do not wish to imply that the page of progress has been blank. On the contrary, as we shall see later, there have been fruitful investigations and observations, chiefly in regard to some of the infections and to shock. There has, however, been no development to change the underlying principles of wound treatment as recognized and practiced before the war. This, in view of the enormous amount of material afforded by the war, might be deemed an admission of failure; but when we reflect that the processes of repair in all wounds, no matter what their cause, are essentially alike, and that these processes have been studied for years, there is little ground for disappointment.

It is extremely interesting to note that this very natural desire to improve upon the accepted methods of wound treatment exerted a profound psychological influence upon surgeons during the first years of the war. It was so great, in fact, as to lead them to discard acknowledged facts and embark on a wild empirical search for a universal panacea for wound infections. In this swing of the pendulum towards antiseptic treatment, not only were the younger and ignorant surgeons involved but also many older men who had passed through the old antiseptic era and should therefore have known better. It was only during the last two

* The LOUIS LIARD lecture, delivered at the Sorbonne, Paris, April 1, 1919.

years of the war that the aseptic principles of wound treatment became re-established, and it is to the credit of France that this was accomplished chiefly by her surgeons.

A brief review of the phases through which the treatment of wounds passed will be to the point.

At the outset of the war military surgeons assumed that the great majority of wounds would result from small arms, *i.e.*, rifle bullets, and that the casualties from high explosives such as shells, bombs and grenades, would be in the minority. It was also thought that rifle bullets would produce clean, neat perforations such as might be made by a large knitting needle. There was no conception of the fact that the full-jacketed bullet could so often cause bursting and shattering effects. Consequently the dictum was that there would be few operations and that only small dressings would be needed; with the result that inadequate provision was made. When the avalanche of wounded descended, with lesions of indescribable magnitude and laceration and mostly containing foreign and infectious material, a demand naturally arose from the overwhelmed surgeons for some means, capable of application by no matter what attendant, to combat the frightful infections which ensued. Thus recourse was had to antiseptics, and the antiseptic era was revived. Our old friends reappeared: phenol, Labarraque's solution, iodoform, the metallic salts and alkaloids, as well as the aromatics of the ancients. Perhaps I should not say *reappeared*, for they were always with us; rather they became dominant. And because they became dominant I feel justified in saying that the early surgery of the war was characterized by retrogression rather than by progression.

No one can deny that antiseptics are of value, but instead of being considered as the basis of treatment they should only be employed as aids and as supplements, and particularly when proper surgical technic is impossible.

Many years before the war it was often remarked that some of the older surgeons, when operating, achieved as good or better results than did the younger men, although the asepsis of the former was questionable, while that of the latter was impeccable. It was easy to find the reason. The older men, most of whom had been trained before the use of general anæsthetics had become prevalent, operated with speed, depended chiefly on the knife, and left clean-cut surfaces; the younger surgeons, often uncertain in their knowledge of anatomy, operated more laboriously, tearing and separating the tissues by blunt dissection and leaving wounds containing shreds of devitalized tissue. Although the older men had introduced many more bacteria, the wounds inflicted by them healed more kindly, very often, than those made by their juniors. In the one case the sound living tissue destroyed the bacteria; in the other the devitalized tissues formed a favorable medium upon which the occasional bacteria could multiply.

The principle that well-nourished tissues can withstand and overcome infection, while, on the other hand, tissues bruised and deprived of their circulation not only cannot destroy bacteria but become actual culture media favoring the development of infection, although perfectly well recognized and understood before the war, was often overlooked and forgotten.

War wounds, particularly those caused by artillery, possess all the conditions which promote infection: the structures are torn and disrupted, masses of tissue, even, may be detached, and, in addition, the projectiles frequently entrain clothing laden with germs.

The treatment of these wounds may be said to have passed through three stages during the war. The first stage was that of *débridement*: the wound was laid open, the foreign materials removed, and the tissues left to eliminate by natural processes those portions which could not live. In order to prevent and combat the fulminating infections resulting from the favorable conditions for bacterial growth, various antiseptics were used, some of which acted directly against the bacteria while others, by a sort of embalming process, rendered the destroyed tissues unfit for bacterial food. The evolution of the wound was characterized by prolonged elimination and suppuration.

The second stage of treatment was that in which substances, such as the hypochlorites, were used to dissolve the destroyed tissues and thereby hasten their elimination. Of these the most commonly used, at least in France, was Dakin's solution, which was applied throughout the wound by Carrel's admirable method of intermittent flushing. The essential value, as I have intimated, of the hypochlorites lies in their solvent properties, which, by getting rid of the pabulum for the bacteria, permit the tissues to sterilize themselves. This treatment finds its chief indication for those wounds to which the complete operative treatment about to be described cannot be applied.

The third stage might be said to have actually commenced early in the war, but it can hardly be stated to have become generalized before the spring of 1917. It might well be called the stage of rational treatment, for it was based upon the principles I have already mentioned, namely, that well-nourished tissues can not only withstand but can eliminate infection. Although this principle was well recognized before 1914 it remained to be proved that it was possible, operating under the unfavorable conditions of war surgery, to systematically convert wounds from hotbeds of infection into simple lesions healing immediately by first intention. It is particularly due to the excellent results obtained and reported by the French surgeons, and especially by Lemaitre, that this treatment became generalized. It consists, briefly, in paring (*épluchage*) the surfaces of the wound, removing all devitalized tissue and foreign materials, and closing it immediately, or, if for certain reasons, this did not seem practicable, leaving the closure to a later date. This rational treatment

has not only been extremely successful, but it has saved an enormous amount of time as well as of expensive dressing materials.

Although the principle of primary suture may not be new, yet rules were formulated for its application, which included organization of personnel and covered questions of transport, hospitalization, etc., and which should be of inestimable value in case of future wars, besides being applicable to a certain extent in civil surgery.

The study of the treatment of wounds is inseparably connected with that of the life history of the infecting organisms, that is to say, bacteriology.

Although the war has thrown practically no new light on the ordinary bacteria of suppuration, *viz.*, streptococci and staphylococci, much has been learned about the organisms producing gas gangrene. It is interesting to note that the treatment of this terrible disease in the early part of the war was also entirely directed against the infecting organisms, while later, it chiefly consisted in removing the conditions favorable to their growth. The bacteria producing gas gangrene all belong to the group known as anaërobes, because they thrive best in the absence of oxygen. A common treatment early in the war was to inject oxygen gas into and about the infected tissues; which did not do much more than increase the gaseous distention and thus produce more pressure upon the already anæmic tissues. Another treatment was to make multiple incisions in the subcutaneous tissues in order to let the gas escape. This might have done good if the gas had been formed in these tissues, but, as was subsequently proved, the gas there was innocuous. It was not until Kenneth Taylor, working in the Robert Walton Goelet Research Laboratory (then at the American Ambulance at Neuilly), proved that gas gangrene was essentially a disease of muscle tissue—not of healthy but of devitalized muscle—that the treatment was put on a rational basis. It then became simple: early excision of all torn and devitalized muscle prevented the development of the disease, and, when the symptoms had already appeared, removal in their entirety of the muscles involved usually stopped it.

Throughout the war attempts were made to treat this disease by antitoxins and sera. Finally, but only during the past year, the French bacteriologists developed anti-sera which have apparently been remarkably successful. It is unfortunate that these discoveries were not made earlier, so that more time might have been available to establish their value; for gas gangrene is an extremely rare disease in civil life and there will be comparatively few opportunities for its clinical study. Yet, from the standpoint of pure science, the study of gas gangrene has unearthed an enormous amount of information in regard to the anaërobes and associated groups which cannot fail to have an influence upon the bacteriology of infection and therefore upon the surgery of the future.

With reference to tetanus, the prophylactic value of the antitoxin was proved, and its use became mandatory in the armies of all the nations instead of optional as had been the case in some. Until then, however,

hundreds of lives were lost because of this lack of appreciation of its value. A profound study of tetanus was carried on during the war, especially in the British army. It was found that the protection afforded by the antitoxin could not be depended upon to last more than from twelve to fourteen days. Thus the occurrence of what is called "late tetanus" was explained, and at the same time its prophylactic treatment was indicated. Studies of the bacterial flora of chronically suppurating wounds show that the tetanus bacillus persists for a long time, especially in and about the dead bone so commonly present in gun-shot fractures. The quiescent germs are apparently innocuous, the system of the individual being protected by the wall of granulation tissue lining the wound. If this living wall be broken down, however, whether by an operation or by rough handling of a fracture, absorption of toxin at once occurs, and, the protection of the original dose of antitoxin having ceased, tetanus ensues. The remedy is evident. Antitoxin must be readministered before any intervention which might destroy the natural barriers of the granulating wound.

The war has contributed greatly to our knowledge and understanding of the condition known as surgical shock. Shock is not only one of the chief causes of early mortality in battle casualties, but is frequently encountered in civil practice; and the importance of any contribution to our knowledge of its cause and treatment can hardly be overestimated. It would take too long to enumerate the theories which have been advanced in regard to the nature and causes of shock. It is sufficient to state that no clear definition of the condition or of its origin existed at the beginning of the war. True surgical shock as we now understand it, psychical shock and hemorrhage were confused with one another, and there were consequently conflicting views as to etiology and treatment. Shock is characterized by a progressive depression of the vital forces as evidenced by weakness of the systemic and cardiac muscles, lowering of bodily temperature, and, finally, death. Hemorrhage causes similar symptoms, and hastens the development of shock; yet pure surgical shock may exist without hemorrhage. It is largely through the investigations of Cannon during the war that a working hypothesis has been reached which affords a reasonable explanation of the phenomena attending shock and at the same time a basis for its rational treatment. Cannon's hypothesis is, briefly, that shock is due to a diminution in the normal alkalinity of the blood caused not only by deficient oxidation but also, more than probably, by the absorption of acid substances produced by the catalysis (*i.e.*, chemical breaking down) of injured muscle tissue. Anything which contributes to deficient oxidation, such as the loss of red corpuscles (hemorrhage) or the reduction of body heat, increases acidosis and, consequently, shock. And as shock produces cardiac weakness and lowering of blood-pressure (resulting in sluggish circulation and therefore in deficient oxidation), a vicious circle is quickly established and the

victim is doomed unless the chain can be broken. It has been found that if external heat be applied to the body, shock may be prevented or even arrested; but if the normal alkalinity of the blood has already undergone a certain diminution, fresh normal blood must be supplied by transfusion in order to restore the alkalinity and increase the blood-pressure and oxygen carriers. Infusions of alkaline solutions are not altogether satisfactory. By transfusion, the patient, having been temporarily resuscitated, is enabled to withstand the operation necessary to remove the crushed and torn muscle tissue, which, if allowed to remain, would again bring about the condition of shock and in any case lead to serious infection.

In order that the treatment of shock could be carried out efficiently, shock teams were organized. The personnel of these teams was generally recruited from the physicians and pathologists attached to the formation, so that the surgeons might be free for the operations. The duties of these teams were to classify the donors, prepare the blood, examine each patient on admission and, if in shock, see that the ordinary means of resuscitation were properly applied, observe the reaction of the patient to the treatment, and, if necessary, give a transfusion. The results obtained were excellent; the patients did not go to the operating room until they were ready to be operated upon, and therefore the operator's time was not lost in determining the condition of the patient and in giving transfusions.

The technic of blood transfusion was so perfected and simplified during the war as to make it far less dangerous, thus extending its use and therefore its value as a therapeutic procedure. One of the chief improvements, and one that might well be adopted for any civil hospital, was the classifying of donors among the personnel, so that blood suitable for any case could be immediately available without having to lose time in finding a donor with blood of the same type as that of the patient.

Much study was given to the effects of the different anæsthetics upon patients suffering from shock. Evidence was obtained by questionnaires sent to all the hospitals, and from discussions in the various meetings held in Paris and elsewhere. The consensus of opinion, which agreed with the laboratory findings, was that all the common general anæsthetics: ether, chloroform, ethyl chloride and nitrous oxide, were harmful, but that nitrous oxide with oxygen was by far the least dangerous. Although the harmfulness of general anæsthetics was admitted, their replacement by local or regional anæsthetics, except to a limited extent, was not considered practicable or justifiable, as the use of the latter is not devoid of danger. The superiority of nitrous oxide given with oxygen is undoubtedly due to the latter, for by its means the oxygen content of the blood is kept at a high point, thus obviating the danger arising from insufficient oxidation.

The result of these conclusions is that probably nitrous oxide with

oxygen will be employed in the future to the exclusion of other general anæsthetics except ether, which will be used as an adjuvant.

During the war considerable advances were made in the surgery of the regions, and particularly in that of the chest. Comparatively little progress was made in abdominal surgery. As regards the nervous system, there were certain improvements in technic and many observations of great value, especially as to the prognosis of certain injuries.

In the surgery of the jaws and face the large amount of material afforded an unprecedented opportunity for the artistic and imaginative surgeon; and some of them developed much skill and ingenuity in overcoming frightful deformities and in bridging dental defects. In this work there were not a few transplants and bone grafts, and future observations as to the permanency and the assumption of new function by these grafts will be of great scientific value.

The surgery of the chest has always possessed a charm for the adventurous surgeon, involving as it does that of the heart and lungs, the most obviously vital organs in the body. An operation on these moving structures will never fail to thrill the most indifferent and cold-blooded surgeon. Before the war the high mortality resulting from intervention for conditions which were then considered to be sufficiently serious to justify operative treatment, impressed surgeons with the idea that operations upon the chest were excessively dangerous. There were an enormous number of chest wounds of all descriptions during the war, with abundant opportunity to observe both their immediate effects and more remote ones, such as those produced by infection. One of the most striking observations was in regard to wounds opening the pleural cavity—the so-called sucking wounds. It was noticed that with such a wound a man got along fairly well for a short time and then rapidly went into shock and died. The reason was, as we have seen in the explanation of shock, a lack of oxidation due to inadequacy of respiration. If the admission of air through the wound were stopped, these cases did as well as those with non-sucking wounds. It became the rule, therefore, to close such wounds as soon as possible, even if they were only provisionally sewn together and had to be operated on and re-closed later. It was found that if shock could thus be prevented the patient could subsequently withstand a formal operation in the course of which the wound of the chest wall could be excised and enlarged, the lung withdrawn if necessary, the wounds in the latter also excised and sutured, and the chest finally closed. Closure of the chest, if only for a day or two to enable the vital functions to become readjusted, was found to be imperative. Naturally, under these conditions, it was of extreme importance that infection should be prevented, and it was therefore necessary to methodically remove foreign bodies, torn and devitalized tissue, and, more particularly, fragments of ribs, which were found frequently to provoke infection. It was seen that extensive exposure and handling of the lungs was possible, and our pre-

war ideas as to the dangers of thoracic surgery became greatly modified. Much was also learned in regard to the treatment of infections of the pleural cavities, including the empyemata caused by pneumonia as well as those due to wounds.

Of all war injuries, the most important without doubt, both from a humanitarian and from an economic standpoint, are those of the bony skeleton; in other words, the fractures, and particularly those of the limbs. Good treatment of fractures saves the use of limbs as well as lives, both for the individual and the nation; conversely, poor treatment cripples limbs and loses lives, and often makes the sufferers a charge upon society. Good treatment lessens by at least one-half or two-thirds the ordinary period of hospitalization, and when we consider that a large percentage of war injuries are fractures and that they require longer treatment than any other injury, the saving effected will be seen to be enormous.

Most surgeons in peace time are not particularly interested in fractures. In the first place, they do not occur in large numbers except in great factory or mining centres, and they do not as a rule appeal to the operating surgeon because they occupy beds for long periods and do not require the particular skill he possesses, or imagines he possesses, but a more purely mechanical one. At the outbreak of war, therefore, there was, generally speaking, a regrettable lack of knowledge as to the treatment of fractures. As a matter of fact, there was no authoritative work or report available on the treatment of war fractures, and what we know now may be fairly said to have been almost entirely acquired during the war. This would be unbelievable were it not for the fact that the war fracture differs greatly from the civil fracture in that it is caused by the direct action of a missile, while the civil fracture is usually the result of an indirect bending or torsional force. The war fracture is open to infection, the bone is smashed by the projectile, fragments of bone are often detached and driven through the tissues so that they actually form secondary missiles; foreign bodies, often loaded with infectious material, lie in or are disseminated amongst the fragments; the soft parts are lacerated, even pulpified; in short, the conditions are all favorable for the severest types of infection. Consequently the surgeon, in treating a war fracture, not only has to keep the fragments of bone in proper position but has also to contend with the worst forms of infection. In order that we may understand the difficulties he has to meet, let us consider what infection of a fracture means. In addition to the immediate danger to life from sepsis it causes death, or as it is called technically, necrosis of the fragments and ends of bone, the amount of necrosis usually depending upon the extent of interference with their blood supply produced by the injury. These dead pieces and ends prolong infection and hinder the processes of repair and union, and have to be removed by operation. If the operations for their removal are not properly timed or executed, more bone may die or other complications follow. There is always a tendency

on the part of the soft tissues to close too rapidly about the dead bone, confining suppuration and thereby causing abscesses to form which often burrow up or down the limb. In short, the clinical course of an infected war fracture is at first a severe infection immediately endangering life, and afterwards a sequence of flares of suppuration of greater or less danger. The gravity of these infectious processes can be greatly modified by skill and proper treatment.

At the outbreak of the war immobilization was the cardinal principle in the treatment.

In order that this should be perfect, the rules, as laid down in the textbooks, required that the articulations on each side of the fracture should also be immobilized. Treatment throughout the early part of the war was therefore consecrated to the principle of immobilization. The limbs, or, if necessary, the limbs and body, were encased in plaster of Paris, windows being cut or bridges of metal being made so as to afford access to the wounds for dressing purposes. What happened? In the first place, as infection developed swelling occurred, and the plaster casts had to be removed, split, or cut away. When this was not done soon enough, gangrene and loss of life were not uncommon results. When it was possible to keep the plaster casts on, wasting of the limbs from disuse made the casts too large, and they no longer fulfilled their purpose. Pressure was exerted in spots, causing sores; and filth accumulated beneath them. In some cases pneumonia developed on account of the fixation of the patient in a recumbent position. And if life and limb were preserved, what result was arrived at after this period of torture? In the best hands, as to union it was fair, although there was generally some shortening; as to function it was, almost without exception, lamentable, the joints were stiffened and the muscles wasted. In fractures of the thigh the results reported by some of the best clinics for the first year of the war show that less than two per cent. were fit to be returned to any kind of duty.

I am happy to state that this deplorable state of affairs no longer exists, and that, with the present methods of treatment, we may expect complete and comparatively early restoration of the use of fractured limbs in the majority of cases. Tissues and structures torn away or destroyed by infection cannot, of course, be replaced.

I do not think I am mistaken when I say that the improvement in treatment has been due to the discarding of the old precepts as to immobilization by fixation and the substitution of entirely different principles. I say *principles*, for the application of the treatment involves several mechanical principles, although the underlying physiological principle may be said to be that of the preservation of function.

The chief mechanical principle involved is that of traction. If traction be made on a broken limb in the direction of the axis of the proximal fragment of the broken bone when in the position of rest, no harmful angulation at the site of fracture will occur. By *position of rest* we mean

the position occupied when no forces are acting on the fragment other than those produced by the muscles attached to it. It has been found that very little external force (*i.e.*, acting from without) is sufficient to materially influence this position. Consequently, if a slight restraining external force be provided, considerable latitude of motion of the joint of which the fragment forms a part may take place without changing the position of the fragment. Now when traction is applied, the confining force provided by the stretched muscles is usually sufficient to furnish the slight external force necessary to prevent motion, and therefore traction in the proper direction may be expected to permit of considerable latitude of motion in the contiguous joints without changing the relative position of the fragments. This is found to be the case. Traction accomplishes more than this, for it also overcomes the tendency to overlapping and shortening. It has also been found that, with traction applied in the proper direction, the bending motion, *i.e.*, angulation, at the site of fracture which may occur in the early days of the injury, is harmless, and that the commencing union rapidly affords the slight restraining force necessary to maintain the relative positions of the fragments.

The problem then is how to maintain traction in the proper direction. It is obvious that if the direction of traction departs too far from that of the axis of the proximal fragment when in the position of rest, angulation will result at the fracture. We cannot overcome this danger by fixation unless it be complete and the joints on both sides of the fracture be immobilized; for, if we fix one side only, the danger is increased. On the other hand, if there be freedom of play on both sides, so that the parts on one side are able to follow any motion of those on the other, the danger is eliminated. This freedom of play is accomplished by suspension, and by removing the point from which traction is made to the farthest distance possible from the site of fracture. Moreover, the point at which traction is made should be, if possible, on the distal fragment itself, so that traction does not have to be made through the joints distal to the fracture, thereby immobilizing them.

The principles of treatment by traction and suspension are most readily applied to fractures of the humerus. It is interesting to note that the first cases treated by suspension and traction were three fractures of the humerus in my service at the American Ambulance at Neuilly in which there was enormous swelling of the forearm and hand. They were suspended in order to relieve the swelling, and it was supposed that some method of fixation would have to be applied when the swelling had disappeared. To our surprise, however, although the arms were swinging freely, union occurred very rapidly. This furnished food for reflection. Evidently immobilization was not indispensable. On the contrary, the nutrition of the limbs was infinitely better, and the motion of the joints was free. Last, but not least, the wounds were accessible and could be dressed without inflicting pain.

The method of applying traction and suspension to fractures of the

humerus has changed but little since that time; but it was found much more difficult to carry out this treatment in the case of the other fractures. Gradually, however, methods have been perfected, so that even in fractures of the femur not only is union without deformity obtained, but the motion of the joints is excellent when union occurs.

The most valuable feature of this treatment is the freedom of motion it affords, not only to the joints but also to the patient in bed. The vital functions are conserved, as well as those of the muscles and joints. We may therefore say that the chief underlying principle of the treatment is conservation of function.

We have learned much during the war in regard to the operative treatment of fractures. Although nothing new has been discovered we have gained great experience in determining the best treatment to follow. In the first place, internal fixation of compound fractures by screws, plates, bands or wires has been proved to be bad practice and unnecessary in view of the improvements I have already mentioned. The tendency at one time was towards the complete excision of all the small fragments in order to prevent infection and the continual suppuration which generally occurs when all the fragments are allowed to remain. Many instances of delayed union or total lack of union followed complete excision, and the present practice is a conservative resection of enough bone to remove contamination and to permit drainage, while at the same time maintaining continuity of the fragments.

The last stage I shall speak of in the treatment of fractures is actually the first, and is the splinting for transport from the battlefield. The inadequate methods employed in this work were one of the cruellest features of the early part of the war. It was not uncommon for wounded to be carried from the field with limbs swinging from the point of fracture, and the jagged fragments tearing and lacerating the tissues. The progress realized later was enormous, and here again was achieved by the use of traction, applied chiefly by means of the Thomas splint. This splint, used by the English orthopædist, Thomas, over fifty years ago, largely as an ambulatory splint for tuberculous affections of the knee, has, with slight modifications in size and form, been of inestimable service, both for transportation and treatment. In fact, with two sizes of this splint nearly all fractures of both upper and lower limbs may be transported and treated with success. It is simple and cheap as far as construction is concerned, but it requires considerable skill in handling. For transport, however, its application is governed by definite and simple rules. It was found, at least in the American army, that the enlisted men quickly became proficient in the application of this splint and were therefore able to splint the wounded where they fell. The latter were thus removed from the battlefield without suffering, and many were saved who would otherwise have died from additional traumatism and shock.

While the Thomas may be said to be the splint of the war, it was in use before the war and the war can only be credited with its generalization.

Perhaps the most efficient splint of all for transportation of fractures of the lower limb is that developed by the French surgeon Pouliquen. This is a happy combination of the Delorme gutter and the long Liston splints, to which attachments for maintaining traction are added. It occupies a very small space and is superior to the Thomas splint for the transportation of fractures of the hip-joint. This splint, I believe, should form a part of the equipment of every civil ambulance in preference to the Thomas.

The principle of conservation of function in the treatment of fractures is well exemplified in the Wilms treatment of wounds of joints. This treatment, introduced about the middle of the war by Doctor Wilms, of Brussels, aims at the retention of motion of the joints by never losing it. The wounded joint is operated upon as usual, the wound "épluchéd," and closed entirely or partially according to whether infection is absent or present. The after-treatment, which is the essential part of the system, is chiefly carried out by the patient himself, and consists in the use of the joint. He begins to move it immediately on regaining consciousness after the anæsthetic, and soon begins to use it. If a knee or ankle, he walks the day after operation. The results have astonished the surgical world. Joints which would have been doomed to ankylosis by the older methods have been perfectly preserved. Everyone who has employed the system agrees that it is marvellous. Some have complained that it lacks the miraculous power of achieving the impossible. This treatment, and the discovery that synovial membranes possess great self-protection against infection, are the two great advances in the surgery of the articulations due to the war.

Of the operations devised during the war, one of the most striking is the kinematic amputation of the Italian surgeon Vanghetti. The object of this operation is to arrange the stump so that the muscles may be used to directly activate the artificial limb, or, in other words, to vitalize the prosthesis. This is, indeed, a distinct advance, and bids fair, judging from the results already obtained, to be a very successful procedure.

So far I have reviewed what, it seems to me, are the chief additions to surgical knowledge and practice which may be credited to the war. In order to form a just opinion, however, as to its influence upon surgical science as a whole, we must place on the other side of the balance those developments which may exert a harmful influence in the future. Happily, these are chiefly habits or practices engendered by the stress and unavoidable cruelty of war, and which will disappear under the softening influence of peace. The courage and the spirit of personal sacrifice evoked are uplifting, but on the other hand there is much that is depressing and demoralizing, especially to the surgeon. Besides the long periods of enforced idleness, there is always the eternal conflict with the insuperable conditions imposed by war. The ordinary soldier is impressed by the dirt and everlasting discomfort; the surgeon is more than likely to be overwhelmed and his *morale* shattered. Overcome by the difficulties with

which he is surrounded, the impossibility of surgical cleanliness, the masses of wounded, he becomes indifferent and callous; he no longer strives for the ideal. If, in addition, he sees his results ruined and his patients lost through official stupidity, this attitude of mind is more than likely to be confirmed. In reality, it requires exceptional strength of character to come through such experiences without deterioration.

As I look back it seems to me that the most reprehensible specific practices resorted to during the war were the guillotine amputation and the general tendency to sacrifice skin. The guillotine amputation is, as its name implies, a chopping off, without the formation of flaps. It always necessitates a secondary amputation, with an additional loss of from 10 to 15 cm. of limb. It was supposed to be exceedingly efficacious for gas gangrene, and actually proved to be so when done above the highest point reached by the disease. When we consider, however, that the extension of gas gangrene is usually confined to a single muscle or group of muscles and can therefore be eradicated by excising these muscles and leaving the others, the fallacy of the argument is exposed. Yet questions of this kind are so difficult of proof that it is possible the guillotine amputation will remain with us for years to come.

The final stage in the influence of the war upon the development of medicine and surgery, lies chiefly in our own hands and depends upon the perpetuation of the cordial and fruitful relations which have existed during the war between the physicians and surgeons of the different armies. It will indeed be regrettable if the stimulus to progress engendered by the meetings of the Interallied Surgical Conference and the Research Committee of the American Red Cross should be permitted to subside. Now is the time to act, while the memory of the events through which we have passed is fresh in our minds and the friendships formed are still warm.

Military organization will have to be supplanted by some other. Shall we look to the national and international societies and congresses, or shall we turn to our great universities? It seems to me that the latter offer the best means for fostering and perpetuating the spirit of enthusiastic coöperation brought about by the war, for they afford opportunities for continuous collaboration and interchanges of ideas. On the other hand, international meetings should be encouraged, not only because of their purely scientific value, but in order to revivify the cordial personal relations which have been such a redeeming feature of the war.

For myself, if I felt that my approaching return to America would be the end of all this, I could not go. I am sure I am voicing the desire of many of my American *confrères* in hoping that in the near future we may have the honor and great pleasure of receiving our European brothers in America in order to be able to make some return for the kind hospitality, the thoughtful helpfulness, and sympathetic appreciation we have always received over here.

FRACTURE OF THE FEMUR*

A CRITICAL ANALYSIS OF 131 CASES OF FRACTURE OF THE FEMUR, TREATED AT THE
AMERICAN RED CROSS HOSPITAL, NO. 2, PARIS

BY KENNETH BULKLEY, M.D.

MAJOR, M. C., U. S. A.; FORMERLY CHIEF OF SURGICAL SERVICE, AMERICAN RED CROSS MILITARY HOSPITAL NO. 2
PARIS, FRANCE

AND

DONALD B. SINCLAIR, M.D.

CAPTAIN, M. C., U. S. A.

It is the object of this paper to analyze statistically 131 consecutive cases of fracture of the femur treated in the American Red Cross Military Hospital No. 2 at Paris. A brief outline of the principles and methods of treatment will also be given, but for the details of the mechanical treatment by traction and suspension the reader is referred elsewhere.¹ The report includes all fractured femurs admitted to the hospital from the time of its opening in April, 1917, to the time of its closure in February, 1919. Of these fractures, 18 occurred in French soldiers and the remainder in members of the American Expeditionary Forces.

The material has, in a way, been selected. We have included in the series only those cases of fracture of the femur in which the weight-bearing femoral stem has suffered a complete loss in continuity. Thus, we have excluded cases of wound of the shaft of the femur without fracture, and cases in which there has been a wound of a trochanter or condyle without loss of continuity of the femoral stem as a whole. Wounds of the knee- and hip-joints in which the articular femoral surface has been the only portion of the femur involved have also been excluded. No cases amputated before admission are herein reported, and no cases of complete union which have passed through our hands merely in transit.

The series should, in many ways, give statistical material of value. It comprises early and late cases, and cases operated upon by many different surgeons, both French and American. Its cases have been operated upon in many different hospitals. It includes cases operated upon only a few hours after injury at field hospitals, and unoperated cases received in Paris during the days of stress in June and July, 1918, four and five days after injury; cases with their primary field dressing still in place—or no dressing at all—and cases with thighs twice their natural size as the result of advanced gas gangrene. It includes cases transported early and late after operation; cases transported with well-applied Thomas splints, cases splinted with German rifles, and cases not splinted

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¹ Blake, *Arch. de méd. et phar. mil.*, Par., 1916, lxvi, 289; Blake and Bulkley, *La Presse Médicale*, No. 64, Nov. 19, 1917; Blake and Bulkley, *Surg., Gyn. and Obstet.*, 1918, xvi, 245.

FRACTURE OF THE FEMUR

at all. The report is thus a composite one, as the hospital functioned for a time as a base hospital situated far behind the lines, and for a time as an evacuation hospital well within the advance area.

The cases were received as follows:

	AFTER INJURY				
	1st week	2nd week	3rd week	4th week	Later
Compound unoperated cases	50	2	0	0	0
Compound previously operated cases	34	4	9	7	16
Simple fractures	6	2	0	0	1
	<hr/> 90	<hr/> 8	<hr/> 9	<hr/> 7	<hr/> 17

The great majority were thus received in less than a week following injury, and considerably over half of these came to us still untreated save for a field dressing and a transportation splint. As practically every case has been under the personal supervision of the writer, uniform observation has been possible.

In a way the series is not representative of the American army. Almost all the cases came from one locality, namely, the triangular area of northern France included between the cities of Chateau-Thierry, Soissons, and Rheims, and the immediately adjacent country. A series of cases drawn from a larger sector of the Western Front would give a far more true picture of the prevalence of infection, for it has been repeatedly shown by various writers that the soil differs markedly in virulence in different localities. And the series is not truly representative of fractures of the femur as they have occurred throughout the war, inasmuch as there are an unusually large percentage of cases wounded by bullets and a correspondingly small number of high explosive fractures. This is explained by the fact that during the period during which the majority of these fractures occurred, the fighting was almost all of the "open" variety, with a constantly changing front line and no prolonged trench warfare. But it is hoped that an analytical study of them may throw some light on the high mortality rate and relatively poor end result of this injury, probably the most serious economic one of the war.

ETIOLOGY

All of these men were injured in the pursuit of war. Sixty-five were injured by bullets, either rifle or machine gun, all sustaining compound fractures. As will be developed later, *some* of these cases healed by primary union without operation, thus falling shortly after injury into the category of simple fractures. Forty-eight were wounded by shell fragments. All of these were compound fractures and remained so. In 8 cases the type of missile was undetermined. All were compound fractures.

There was but 1 injury by shrapnel ball. There were 9 simple fractures; 5 by motor vehicle accident, 3 by falls from a height, and 1 by the blow of an aeroplane propeller. There were no fractures by hand grenades. The relative amount of injury caused by the different types of missile and the relation of these latter to infection will be considered under Pathology.

PATHOLOGY

Side Involved.—The right femur was fractured in 68 cases, the left in 59 cases; there was 1 fracture of both femora, and in 2 cases the data are lacking.

Site of Fracture.—The neck of the femur was involved in 8 cases (6.1 per cent.), the upper third of the shaft in 24 cases (18.2 per cent.), the middle third in 56 cases (42.7 per cent.), and the lower third in 41 cases (30.9 per cent.). In 2 cases of double fracture, the upper and lower thirds were both involved, leaving isolated central fragments.

Joint Involvement.—In all 7 cases of compound fracture of the neck of the femur (one case was a simple fracture), the hip-joint was involved and every case suppurated irrespective of the type of treatment used. In 12 of the 41 cases of fracture of the lower third, the knee-joint was involved by splitting or communication into the joint cavity. Irrespective of the level of the femoral fracture, an effusion into the knee-joint may occur. It is usually serous but may be bloody. It is a true, rather transitory, traumatic arthritis, the trauma being transmitted from the site of impact of foreign body along the shaft of the bone to the joint. In fractures of the lower third of the femur it is often difficult to decide whether the joint effusion is due to a traumatic arthritis thus transmitted or due to a splitting directly into the joint cavity. We have seen a number of cases in which the radiograph failed until the fourth or fifth picture to demonstrate the fissure, due to the fact that plates were made only in an antero-posterior and lateral plane. In cases of this nature in which there is a doubt, it is advisable to take oblique plates.

Type of Fracture.—In the majority of these cases the fracture was comminuted, often extensively, with fragments of bone buried at some distance from the site of fracture in the surrounding muscles. Vertical splitting was common, frequently resulting in the separation from the shaft of the bone of a large wedge-shaped fragment involving the entire thickness of the cortex. From one or the other end of such a fragment the continuity of the periosteum with that of the shaft was usually preserved, a point of importance in the operative treatment of these cases. The amount of comminution did not seem to depend to any great degree on the type of missile. Machine-gun and rifle bullets frequently caused as extensive a comminution as did shell fragments of similar size. Missiles of low velocity, usually remaining *in situ*, and particularly those striking the femur just below the trochanters, caused more comminution than those moving at a greater speed and striking other portions of the

SYNOPSIS OF 131 CASES OF GUNSHOT FRACTURE

Serial number	Admitted	Side involved	Situation	Etiology	First operation	Second operation	Third operation	Fourth operation	Amputation	Resection	Disarticulation	Gas	Ice tongs, long traction			Steinman pin traction		
													Inserted	Removed	Reason	Inserted	Removed	Reason
1	27	L	U	S	1	97	..	..	..	..	..	..	..	..	..	..	..	..
2	48	L	M	S	2	62	149	187	..	..	..	..	..	..	..	..	..	..
3	50	L	M	S	1	152	..	..	..	..	..	..	..	..	..	..	..	..
4	75	R	U	S	1	31	94	..	..	..	..	..	..	..	..	94P	143	..
5	55	L	U	S	1	..	..	..	..	..	..	..	..	..	..	..	..	..
6	22	L	M	S	1	..	..	..	..	..	..	..	..	..	..	..	..	..
7	34	R	L	S	1	77	99	109	..	..	..	..	..	..	..	..	..	..
8	38	L	N	Fall	..	..	..	..	..	..	..	..	..	..	..	..	..	..
9	44	R	L	S	1	53	..	..	..	..	..	..	..	..	..	53P	81	..
10	9	R	M	Fall	..	..	..	..	..	..	..	..	..	..	..	..	..	..
11	9	R	M	Fall	..	..	..	..	..	..	..	..	..	..	..	..	..	..
12	37	L	L	B	1	41	..	..	41	..	..	..	..	..	..	..	..	..
13	1	R	U	B	..	..	..	..	..	..	..	..	13	50	Union.....	..	..	..
14	2	R	U	B	2	4	6	..	6	..	..	Yes	..	..	..	..	..	..
15	1	L	M	B	1	100	..	..	..	..	..	..	11	52	Union.....	..	..	..
16	1	L	M	B	2	4	..	..	..	..	..	Yes	..	..	..	..	..	..
17	2	R	U	B	2	..	..	..	..	..	..	Yes	12	49	Union.....	..	..	..
18	3	L	U	B	3	15	..	..	3	..	15	Yes	..	..	..	..	..	..
19	2	R	U	B	2	46	93	119	..	..	..	..	..	..	..	11	53	Union.....
20	2	L	U	S	2	19	..	..	2	..	19	Yes	..	..	..	..	..	..
21	2	L	M	B	2	11	15	..	..	..	..	Yes	..	..	..	..	..	..
22	2	R	M	B	3	62	..	..	..	..	..	..	9	60	Union.....	..	..	..
23	2	L	U	B	2	55	..	..	..	..	..	Yes	9	38	Union.....	..	..	..
24	2	L	L	S	1	20	41	53	53	..	..	..	..	..	..	11	53	Amputated.....
25	2	R	U	B	1	30	..	..	..	..	..	..	..	..	..	7	48	Death.....
26	3	R	U	S	3	54	72	..	..	..	..	..	9	50	Union ?.....	54	78	Slight infection...
27	2	L	L	S	2	54	56	..	..	..	..	..	..	..	..	..	..	..
28	2	R	M	S	1	..	..	..	..	..	..	..	..	..	..	..	..	..
29	3	R	M	B	1	37	75	107	..	..	..	..	..	..	..	11	53	Union.....
30	1	R	M	Motor-cycle	1	..	..	..	..	..	..	..	..	..	..	..	..	..
31	2	L	M	S	2	..	..	..	..	..	..	..	10	30	Slight infection...	..	..	..
32	2	R	N	Ball	2	6	21	60	..	21	..	..	..	..	..	..	..	..
33	3	R	L	S	3	..	..	..	3	..	..	Yes	..	..	..	..	..	..
34	5	L	M	S	1	8	11	..	11	..	..	Yes	..	..	..	..	..	..
35	3	R	M	?	?	3	5	10	10	..	..	Yes	..	..	..	..	..	..
36	3	L	M	S	1	29	46	70	70	..	..	..	..	..	..	3	47	Slight infection...
37	3	R	M	?	1	3	..	..	3	..	..	Yes	..	..	..	..	..	..
38	2	R	M	S	2	3	..	..	..	..	..	Yes	..	..	..	..	..	..
39	1	R	M	B	..	..	..	..	..	..	..	..	6	18	Slight infection...	..	..	..
40	1	L	M	B	17	40	..	..	..	40	..	..	7	40	Amputated.....	..	..	..
41	1	R	M	B	1	18	..	..	18	..	..	Yes	..	..	..	..	..	..
42	2	R	L	B	13	..	..	..	..	..	..	..	8	44	Union.....	..	..	..

FRACTURE OF THE FEMUR TREATED AT THE AMERICAN RED CROSS HOSPITAL, NO. 2, PARIS

Reason	Associated lesions	Complications	Blood culture	Wound culture	Died	Evacuated	Remarks
	F.C.C. phalanges with amputation. G.S.W. buttock	Long slow sequestration		30, H.S. and Bac.	167	167	Union 85; refracture 93, for poor position.
				236, H.S.	285	285	Very poor result. Had had complete transverse debridement of quadriceps group. Fifth operation, 197; sixth operation, 236; both for secondary abscesses.
	F.C.C. humerus with division musculo-spiral			182, neg.; 196, neg.	247	247	
				194, neg.; 217, neg.	270	270	Refractured 94, for poor position. Accidentally refractured 158.
					136	136	Musculo-spiral later sutured.
		Suppurative arthritis, right knee and ankle		23, neg.; 42, neg.	85	85	Knee penetrated by missile. Primary arthrotomy closed successfully without suppuration.
	F.C.C. fingers with amputation. Multiple G.S.W. soft parts	Simple fracture		96, neg.; 34, neg.	223	223	Hæmolytic streptococcus from both knee and ankle. In view of disability patient should probably have been amputated.
		Simple fracture		67, Bac.	94	94	Bacillus aerogenes capsulatus grown from piece of cloth removed from wound on 67th day. Overriding corrected by gin.
		Suppurative L. knee			121	121	
	Multiple severe G.S.W. soft parts			Primary union	119	119	Amputated for sepsis. Original wound involved knee. Knee opened at primary operation.
	Multiple G.S.W. soft parts			4, Bac. and H.S.	7	7	Consolidation very slow. Much lead splattering.
				11, neg.; 19, H.S.; 30, 41, 108, neg.	120	120	Autopsy showed nothing but gas gangrene of stump.
				7, Bac.	12	12	Very slow union.
	Gassrotum. Cut urethra. G.S.W. L. thigh.		64, neg.		215	215	Autopsy showed an acute gas gangrene limited to the thigh. Should have been amputated.
	G.S.W. L. thigh		17, H.S.	14, H.S.	19	19	Persistent bowing for 188 days. Walking on 205th day.
			36, neg.	17, neg.; 25, H.S.; 27, neg.; 52, H.S.; 96, 110, neg.	167	167	At autopsy a generalized streptococcus infection without localisation. Beginning union under 50 days. Delayed by slow sequestration.
				13, Bac. and H.S.	30	30	Disarticulated because of short stump.
					16	16	Nothing definite at autopsy other than a progressive gas gangrene of thigh. Should have been amputated.
	G.S.W. R. thigh by same missile		36, neg.	8, Bac.; 16, H.S.; 21, neg.; 35, H.S.; 43, 65, neg.; 101, 109, neg.	119	119	Long slow sequestration. Terminal sequestræ resulting in much loss of substance.
				14, Bac., and H.S.; 25, H.S.	61	61	Good union on 50th day. Went to pieces after sequestrectomy. Autopsy showed practically nothing but gas in thigh probably stirred up by sequestrectomy.
			38, neg.	9, neg.; 23, neg.; 37, 43, H.S.; 45, neg.; 46, H.S.	73	73	Pin stayed clean. Amputated for extreme sepsis. Remarkably quick improvement in general condition following amputation. This patient would undoubtedly have died had not amputation been done when it was. Should have been amputated sooner.
	F.C.C. R. tibia		31, H.S.	13, 16, 21, 45, 35, all H.S.	48	48	Pin stayed clean. Died of chronic sepsis. Should have been amputated.
			50, neg.	102, neg.	119	119	Persistent tendency to outward bowing.
				13, H.S.; 22, H.S.; 30, 37, 51, neg.; 60, H.S.	118	118	Walking 117.
	G.S.W. wrist and elbow				61	61	Very little available data. Ran a long septic course before recovery.
	G.S.W. opposite thigh with gas gangrene			17, 22, 36, neg.	116	116	
		Simple fracture			85	85	Transverse fracture. Immediate operative reduction with insertion of Lane plate. Primary union.
				Primary union	80	80	Union 48. Removed from apparatus 69. Walking 79. Operated and closed without drainage. Remained clean.
	F.C.C. radius and ulna			57, H.S.; 65, Bac.; 82, H.S.; 86, 100, Bac.	112	112	Ankylosis at hip well established at time of evacuation.
	G.S.W. of heel				16	16	Uneventful after sausage amputation.
					17	17	Autopsy showed a gas gangrene limited to the stump. Should have been amputated on admission.
			48, neg.; 67, neg.	4, Bac.; 50, Bac.	76	76	First and second operations markedly insufficient.
					19	19	Always septic. Should have been amputated sooner. Autopsy showed general sepsis. Suppurative arthritis of the shoulder, a terminal bronchopneumonia, a double empyema, peritonitis.
					5	5	Autopsy showed nothing but gas gangrene localised to the thigh. Was never amputated. Should have been amputated on admission.
			29, neg.	Primary union	75	75	Union 44. Out of splint 65. Walking 75.
		Acute gastric dilatation. Secondary hemorrhage		40, neg.	40	40	Hæmolytic streptococcus obtained from heart's blood at autopsy. General sepsis. Died of shock. Amputated too late.
				Primary union	19	19	Amputated for severe hemorrhage. Autopsy showed gas gangrene of stump.
					75	75	By ice-tong traction it was impossible to reduce a double "church-spire" fracture. Open reduction accordingly done and fragments sutured. Primary union and excellent anatomical and functional result.

URE OF THE FEMUR TREATED AT THE AMEL

Associated lesions	Complications	Blood culture
F.C.C. phalanges with amputation. G.S.W. buttock	Long slow sequestration	
F.C.C. humerus with division mus- culo-spiral	Suppurative arthritis, right knee and ankle Simple fracture	
F.C.C. fingers with amputation. Multiple G.S.W. soft parts	Simple fracture Simple fracture Suppurative L. knee	
Multiple severe G.S.W. soft parts		
Multiple G.S.W. soft parts		
Gasscrotum. Cut urethra. G.S.W. L. thigh.		64, neg.
G.S.W. L. thigh		17, H.S. 36, neg.
		36, neg.
G.S.W. R. thigh by same missile		38, neg.
		31, H.S. 50, neg.
G.S.W. wrist and elbow. G.S.W. opposite thigh with gas gangrene	Simple fracture	
F.C.C. radius and ulna		
G.S.W. of heel		48, neg.; 67, neg.
		29, neg.
	Acute gastric dilatation. Secondary hemorrhage	

THE AMERICAN RED CROSS HOSPITAL, NO. 2, PARIS

Wound culture	Died	Evacuated	Remarks
30, H.S. and Bac.	167		Union 85; refracture 93, for poor position.
236, H.S.	285		Very poor result. Had had complete transverse debridement of quadriceps group. Fifth operation, 197; sixth operation, 236; both for secondary abscesses.
182, neg.; 196, neg.	247		Refractured 94, for poor position. Accidentally refractured 158.
194, neg.; 217, neg.	270		Musculo-spiral later sutured.
23, neg.; 42, neg.	85		Knee penetrated by missile. Primary arthrotomy closed successfully without suppuration.
96, neg.; 34, neg.	223		Hæmolytic streptococcus from both knee and ankle. In view of disability patient should probably have been amputated.
67, Bac.	94		Bacillus aerogenes capsulatus grown from piece of cloth removed from wound on 67th day. Overriding corrected by gin.
	129		
	121		
	121		
	52		Amputated for sepsis. Original wound involved knee. Knee opened at primary operation.
Primary union.	119		Consolidation very slow. Much lead splattering.
4, Bac. and H.S.	7		Autopsy showed nothing but gas gangrene of stump.
11, neg.; 19, H.S.; 30, 41, 108, neg.	120		Very slow union.
7, Bac.	12		Autopsy showed an acute gas gangrene limited to the thigh. Should have been amputated.
	215		Persistent bowing for 188 days. Walking on 205th day.
14, H.S.	19		At autopsy a generalized streptococcus infection without localization.
17, neg.; 25, H.S.; 27, neg.; 52, H.S.; 96, 110, neg.	167		Beginning union under 50 days. Delayed by slow sequestration.
13, Bac. and H.S.	30		Disarticulated because of short stump.
8, Bac.; 16, H.S.; 21, neg.; 35, H.S.; 43, 65, neg.; 101, 109, neg.	16		Nothing definite at autopsy other than a progressive gas gangrene of thigh. Should have been amputated.
14, Bac., and H.S.; 25, H.S.	119		Long slow sequestration. Terminal sequestræ resulting in much loss of substance.
9, neg.; 23, neg.; 37, 43, H.S.; 45, neg.; 46, H.S.	61		Good union on 50th day. Went to pieces after sequestrectomy. Autopsy showed practically nothing but gas in thigh probably stirred up by sequestrectomy.
13, 16, 21, 45, 35, all H.S.	73		Pin stayed clean. Amputated for extreme sepsis. Remarkably quick improvement in general condition following amputation. This patient would undoubtedly have died had not amputation been done when it was. Should have been amputated sooner.
102, neg.	119		Pin stayed clean. Died of chronic sepsis. Should have been amputated.
15, H.S.; 22, H.S.; 30, 37, 51, neg.; 60, H.S.	118		Persistent tendency to outward bowing.
17, 22, 36, neg.	61		Very little available data. Ran a long septic course before recovery.
	116		
Primary union.	85		Transverse fracture. Immediate operative reduction with insertion of Lane plate. Primary union.
57, H.S.; 65, Bac.; 82, H.S.; 86, 100, Bac.	80		Union 48. Removed from apparatus 69. Walking 79. Operated and closed without drainage. Remained clean.
	112		Ankylosis at hip well established at time of evacuation.
	16		Uneventful after sausage amputation.
	16		Autopsy showed a gas gangrene limited to the stump. Should have been amputated on admission.
4, Bac.; 56, Bac.	17		First and second operations markedly insufficient.
	76		Always septic. Should have been amputated sooner. Autopsy showed general sepsis. Suppurative arthritis of the shoulder, a terminal broncho-pneumonia, a double empyema, peritonitis.
	19		Autopsy showed nothing but gas gangrene localized to the thigh. Was never amputated. Should have been amputated on admission.
Primary union.	75		Union 44. Out of splint 65. Walking 75.
40, neg.	40		Hæmolytic streptococcus obtained from heart's blood at autopsy. General sepsis. Died of shock. Amputated too late.
	19		Amputated for severe hemorrhage. Autopsy showed gas gangrene of stump.
Primary union.	75		By ice-tong traction it was impossible to reduce a double "church-spire" fracture. Open reduction accordingly done and fragments sutured. Primary union and excellent anatomical and functional result.



FRACTURE OF THE FEMUR

bone. As far as could be determined, in all but 3 cases of this series the fracture took place only at the point of impact of the missile. In these 3 cases fracture apparently occurred by *contre coup*. In one of these a shell fragment about 1 cm. in diameter struck the femur just below the trochanters, fracturing it at that point and also at a point 5 inches below. The fragment was in this case retained. In a second case a bullet, after traversing the knee-joint without bony injury, entered the opposite thigh, drilled cleanly through the shaft of the femur without fracturing it at the point of impact, and caused an oblique fracture of the shaft at a point 4 inches above the site of bone wound (Fig. 1). This bullet was undoubtedly travelling at an extremely high velocity. The wound of the knee-joint and that of the thigh both healed by first intention without operation, resulting in a hæmarthrosis which quickly disappeared with aspiration and a fracture of the femur which clinically could be considered for purposes of treatment as a simple fracture. In a third case a machine-gun bullet struck the upper third of the femur, fracturing it at that point and remaining *in situ*. There was also a second fracture 4 inches below this point.

Associated Injuries.—These may be divided into those directly connected with the fracture and those situated in some other portion of the body. In every compound fracture there is by definition an associated injury of the soft parts. The muscles are invariably injured, the degree of damage being in direct proportion to the cross section of the impacting surface of the missile and to the amount of comminution of bone. It depends also to a considerable degree on the perfection of immobilization during transportation. The muscle is frequently injured at a considerable distance from the site of fracture by bony fragments driven into it at the moment of impact of missile and femur. Thus we have seen a localized gas gangrene of the sartorius, a muscle which at no point touches the femur, due to the burying in it of a fragment of bone. This muscle had at no point been injured by a missile. Other than muscle injury, we have observed relatively few injuries of the thigh associated with fracture of the femur. There was one case of division of the sciatic nerve. The larger muscular branches of the anterior crural nerve were frequently found divided, but no accurate records of these findings were kept. There were no cases of division of the main femoral artery, although frequent examples of the division of the various larger muscular branches were encountered. There was one case of division of the superior perforating branch of the profunda femoris which caused at operation an annoying hemorrhage difficult to control. The posterior tibial artery was divided in one case by a missile passing in an oblique direction and causing also a fracture of the tibia. Of the injuries of the soft parts of the thigh associated with fracture of the femur, we consider that of the muscles to be most important because of the possibility of ensuing gas gangrene.

Of the 119 compound cases of this series, 28 or 23.5 per cent., had associated injuries other than those of the thigh. The following table briefly indicates their character:

Comp. fract. tibial head (one case having in addition a fract. of the tibia and a divided posterior tibial artery)	2
Comp. fract. tibial shaft	1
Comp. fract. patella	1
Comp. fract. humerus with divided musculospiral nerve	1
Comp. fract. radius with multiple gun-shot wounds of soft parts	2
Comp. fract. radius and ulna	1
Comp. fract. hand phalanges	3
Comp. fract. bones of elbow-joint necessitating resection of elbow	1
Comp. fract. carpal bones with through-and-through wound of elbow-joint	1
Gun-shot wound of knee-joint without bony injury	2
Division of sciatic nerve and comp. fract. metatarsals	1
Division of urethra	1
Multiple gun-shot wounds of soft parts, some of them severe	11

The femoral lesion was thus in the majority of the cases of the series the most serious injury received.

Infection.—Attention has been repeatedly called to the fact that the American army is particularly susceptible to infection, especially with the streptococcus. No attempt will be here made to discuss this susceptibility other than to take cognizance of the fact, as considerable discrepancy will probably be noted between our figures and those of our British and French colleagues working with their own troops. We regret that our data on these cases are not more complete, especially that the results of the cultures made from the wounds on admission are not all available. In the main only two types of organisms have been searched for, streptococci and one of the gas-producing pathogenic anaërobes. In all cases where the streptococcus has been found, its hæmolytic or non-hæmolytic capability has been determined. In the cases of the anaërobes their presence or absence only has been noted. Our ideal has been to take a culture from every wound on admission and at weekly intervals thereafter, occasionally more often, but in the rush of work this ideal was far from realized. Accordingly the bacteriological portion of the report must be considered as far from complete.

Gas Gangrene.—Twenty-seven cases of this series, or about 23 per cent. of the compound fractures, on admission or shortly after admission showed *clinical* evidence of gas gangrene, in some of the cases far advanced. In one case there was no gangrene of the involved thigh, but marked gangrene was present in the calf of the same leg, due to the passage of a second missile. In a second case there was a gas gangrene of the opposite thigh. Some had been operated upon previous to admission, some had not. In some the infection was not noted for a number of days following admis-

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sion. The clinical diagnosis was made by the usual train of symptoms: increased pulse rate in relation to temperature; abnormal pain; increased size of the limb; copper discoloration; distended cutaneous venules (of particular value in cases of deep gas infection in which the main muscular sheaths have not as yet ruptured, and possibly explained by the interference with the deep return venous flow); subcutaneous or intramuscular crepitus; change in percussion note of the limb; exploratory aspiration; and at operation by the appearance of the subcutaneous tissue and muscles themselves. The infection frequently involved an isolated muscle or group of muscles, at times extending practically from origin to insertion. In cases of advanced and widespread gangrene it was common to find the sheath of the femoral vessels or of the sciatic nerve acting as a path along which the gas spread. The fascial sheath of the involved muscle was invariably tense, so that on incision the underlying muscle protruded. The areolar tissue surrounding a muscle group was cedematous. Subcutaneous gas on the anterior abdominal wall was not an infrequent finding.

It is of interest to note the time after injury at which these cases of gas gangrene came under observation, and the type of missile which caused the injury. Of the 27 cases, 12 had been previously operated upon. They were admitted to our service on the following number of days after injury: second day, 1 case; third day, 3 cases; fourth day, 1 case; fifth day, 3 cases; sixth day, 1 case; seventh day, 1 case; eighth day, 2 cases. We amputated 6 of these cases immediately on admission because of their general condition, the advanced state of their gangrene, and the severity of the bone injury. Of the remaining 6 cases all were also immediately re-operated, extensive débridements being done. Of these, 1 was never amputated, dying on the twelfth day. Autopsy showed no cause of death other than a progressive gas gangrene. The other 5 cases were amputated on the seventh, ninth, ninth, tenth, and eleventh days, respectively. (For death rate of these cases, see later under Mortality.)

Of the 15 cases admitted with gas gangrene and not previously operated, all were immediately operated upon. They were admitted as follows: first day, 2 cases; second day, 9 cases; third day, 2 cases; fourth day, 2 cases. Four were immediately amputated. The remaining 9 were immediately débrided. Of these, 3 were subsequently amputated. Thus 18 of 27 cases of fracture of the femur with associated *clinical* gas gangrene were sooner or later amputated. As we will show in discussing the treatment, more should have been amputated primarily.

Of the 27 cases, 12 were wounded by shell, 10 by bullet, and in 5 cases the type of missile was undetermined. Referring back to our total number wounded by the two types of missile, we find that 15 per cent. of the fractured femurs caused by machine-gun or rifle fire developed clinical gas gangrene as against 25 per cent. of those wounded by shell fragments. This is probably accounted for by the relative amount of clothing carried

into the wound, the clothing in the majority of instances rather than the missile itself being responsible for the ensuing infection.

It has been our practice to depend more on the clinical evidence of anaërobic infection than on the laboratory findings from wound cultures. However, it may be of interest to note briefly such bacteriological data as we have at hand on this subject. There are positive bacteriological anaërobic findings in 14 cases which clinically at no time during their course showed gas. In some of the cases of this series wound cultures showed the presence of anaërobic bacilli up to as late as 100 days after injury. In every instance this finding was in a case of long slow sequestration with retained fragments. The finding is not an unusual one, but is cited simply to emphasize the fact that anaërobic cultural findings do not necessarily imply the presence of an active clinical anaërobic infection. In one case the *Bacillus aerogenes capsulatus* was isolated from a piece of cloth removed from the wound sixty-seven days after injury.

Before leaving the subject of gas infection, we wish to call attention to a particular type of injury which almost invariably results in an anaërobic infection. We refer to the cases in which a missile passes transversely through the upper portion of a thigh, then through the perineum or just below it, and enters or passes through the opposite thigh. There were 5 injuries of this type in this series, all developing gas gangrene. In one case the thigh first struck was fractured. In the other 4 cases the fracture occurred in the second thigh. In all 5 cases the second thigh struck developed gas whereas the first thigh remained clean. Although we have not the figures before us, we are strongly of the impression that among similar wounds of the soft parts without fracture which came under our observation, the same phenomenon was frequently observed. This observation does not hold true for wounds 6 inches or more below the perineum.

Streptococcus Infection.—It is rather more difficult to give definite figures in relation to the incidence of streptococcic infection among this group of cases, but it has been all too frequent. It has been responsible for some of the early deaths and, with the exception of a lobar pneumonia, for all the late deaths, either directly or indirectly. It has been responsible for the large majority of complications. In 25 of these cases blood culture records are available. There was one positive pneumococcus finding, the case having a lobar pneumonia and recovering. There were 8 cases with positive streptococcus blood culture which died. There was one case with a positive culture which recovered. There were 11 cases suspected of harboring the organism in the blood stream whose cultures all remained sterile. All these recovered. There were 4 cases of chronic sepsis with multiple streptococcus abscesses which died, but from which positive cultures before death could never be obtained. In one of these the streptococcus was obtained at autopsy from the heart's blood. The streptococcus in every instance belonged to the hæmolytic group.

SYNOPSIS OF 131 CASES OF GUNSHOT FRACTURE OF THE FEMUR TREATED

Serial number	Admitted	Side involved	Situating	Etiology	First operation	Second operation	Third operation	Fourth operation	Amputation	Resection	Disarticulation	Gas	Ice tong, long traction			Steinman pin traction			Associated lesions	Complications
													Inserted	Removed	Reason	Inserted	Removed	Reason		
43	2	L	U	B	3	..	..	..	..	..	..	..	..	..	..	15	34	Slight infection...	G.S.W. R. knee joint.....	
44	4	L	M	B	2	6	76	..	..	..	..	..	8	38	Slight infection...	..	..	..
45	2	L	M	B	2	..	..	..	..	..	..	..	8	13	Evacuated.....	..	..	..	Diphtheria.....	
46	2	R	M	B	24	34	..	..	..	..	..	..	5	21	Slight infection...	..	..	..
47	1	R	M	B	37	..	..	..	..	..	..	..	1	15	Slight infection...	15	58	Death.....	G.S.W. L. thigh.....	
48	2	L	U	B	..	..	..	..	..	..	..	..	4	40	Union.....	..	..	..
49	2	R	U	?	3	35	..	..	35	..	..	..	..	..	..	..	..	..
50	2	R	M	S	2	..	..	..	..	..	..	Yes	..	..	..	..	..	..	Multiple G.S.W. soft parts.....	
51	2	R	M	?	?	6	..	..	6	..	..	Yes	6	26	Slight infection...	..	..	..	F.C.C. hand phalanges.....	
52	6	R	L	?	?	..	..	..	..	..	..	..	..	..	..	..	..	..
53	1	L	N	S	1	8	..	..	8	..	..	Yes	..	..	..	..	..	..	Tetanus.....	
54	3	L	U	?	3	20	..	..	..	..	..	Yes	..	..	..	..	..	..
55	5	L	M	?	?	5	14	..	5	..	..	Yes	..	..	..	..	..	..	G.S.W. soft parts.....	Secondary hemiparesis.....
56	4	R	U	B	2	63	..	..	..	..	..	..	7	61	Union.....	..	..	..
57	1	R	U	B	2	15	..	..	15	2	..	..	3	17	Pain.....	..	..	..	Femoral condyle and tibial head involved	
58	2	R	L	S	..	..	..	..	..	..	..	..	..	..	..	..	..	..
59	2	R	L	B	?	3	63	..	..	..	..	..	5	43	Union.....	..	..	..
60	2	R	L	S	?	4	..	..	4	..	..	Yes	..	..	..	9	50	Union.....		
61	4	R	L	?	?	7	..	..	7	..	..	Yes	..	..	..	..	..	..
62	3	R	L	S	14	23	43	47	47	..	..	..	6	38	Infection.....	..	..	..
63	4	R	L	S	..	..	..	..	..	..	..	..	..	..	..	..	..	..
64	3	R	U	B	3	..	..	..	..	..	..	..	6	35	Pain.....	..	..	..
65	2	R	U	B	2	53	..	..	..	..	..	Yes	..	..	..	..	..	..
66	1	R	U	B	1	2	19	62	..	..	..	..	4	33	Union.....	..	..	..
67	2	R	U	B	..	..	..	..	..	..	..	..	5	40	Slight infection...	..	..	..
68	5	R	M	B	1	..	..	..	..	..	..	..	..	..	..	7	31	Slight infection...		
69	7	L	M	B	1	16	33	52	..	..	..	..	..	..	..	8	45	Union.....		
70	4	R	M	B	3	..	..	..	..	..	..	..	..	..	..	..	..	..
71	8	R	M	B	2	36	75	80	80	..	..	..	..	..	..	..	..	..	Suppurative infection	
72	2	R	U	B	1	..	..	..	..	..	..	..	3	43	Union.....	..	..	..
73	3	R	U	B	1	48	..	..	..	..	..	..	..	..	..	3	45	Slight infection...		
74	1	R	M	Propeller	..	..	..	..	..	..	..	..	..	..	..	..	..	..
75	1	R	M	R	..	..	..	..	..	..	..	..	..	..	..	..	..	..
76	4	R	M	S	1	..	..	..	..	..	..	..	..	..	..	..	..	..	Tetanus.....	
77	3	R	N	B	1	11	43	91	..	43	..	..	4	40	..	..	..	..	Extraperitoneal abscess	
78	2	L	N	B	1	3	..	..	..	..	..	..	4	29	Pain.....	..	..	..	Lobar pneumonia	
79	17	R	N	B	1	109	140	151	..	..	..	..	18	53	Union.....	..	..	..	Influenza peritonitis	
80	15	L	M	B	1	54	72	..	..	54	..	..	..	..	..	..	..	..
81	23	R	U	?	1	..	..	..	..	..	..	..	..	..	..	..	..	..
82	23	R	L	?	1	..	..	..	..	..	..	..	..	..	..	..	..	..
83	23	L	M	B	2	52	..	..	..	..	..	..	..	..	..	..	..	..
84	23	L	M	B	63	..	..	..	..	..	..	..	..	..	..	..	..	..
85	1	R	M	Motor-cycle	..	..	..	..	..	..	..	..	..	..	..	..	..	..
86	25	L	M	B	1	..	..	..	..	..	..	..	..	..	..	..	..	..	Fractured patella.....	
87	19	L	M	B	2	38	110	..	..	..	..	..	96	100	..	..	..	..
88	25	L	M	S	?	30	35	35	30	F.C.C. radius. G.S.W. soft parts..	
89	17	L	N	S	1		
90	2	L	M	Auto	26	68	Union.....		



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There are wound cultures available from 76 cases. In 43 of these cases the streptococcus was at some time found, in 12 cases being associated with the bacillus *aërogenes capsulatus*. In the remaining 32 cases the cultures proved negative. Referring again back to the total number wounded by the two types of missile, we find that 30 per cent. of the cases wounded by bullet developed streptococcus wounds, and 43 per cent. of the cases wounded by shell. It is an open question as to whether a certain number of these cases of streptococcus wound infection are not "hospital" or "ward" infections. Unfortunately, our data are not sufficiently complete to settle this point, as the proportion of cases in which a culture was obtained and recorded from the admission to the discharge of the case is not sufficiently large for study.

There were 2 cases of latent infection, both fatal, which seem worthy of particular note. Both were wounded by machine-gun bullets and both died as the result of streptococcus infection. The first case was received twenty-four hours after injury, having been wounded by a bullet which had entered and lodged in the right thigh, causing an oblique fracture of the mid-third of the femur. There was no indication for operative interference and except for the mechanical treatment of the fracture the patient was not disturbed for twenty-eight days. His temperature, which previous to that time had been normal without fluctuation, then became irregular, and on the thirty-seventh day after injury an abscess about the site of fracture was opened and the bullet removed. No clothing was found. A pure culture of hæmolytic streptococcus was obtained from this abscess. The patient developed a streptococcus sepsis with positive blood culture and died on the fifty-eighth day. At autopsy there was no union and a multiple suppurative streptococcus arthritis was found.

The second case was also received twenty-four hours after injury, a machine-gun bullet having passed through the left thigh, causing an oblique fracture of the mid-third of the femur. There was no indication for operative interference, the temperature remained normal for eight days and the small points of entry and exit apparently healed by first intention. On the eighth day the temperature began to become irregular, but nothing definite could be found until the seventeenth day, when an abscess was found and opened at the site of fracture. This yielded a pure streptococcus. Blood culture and culture from wound were repeatedly negative. The leg became a mass of dissecting pus pockets and finally on the fortieth day a disarticulation at the hip was done. In the meantime the patient had developed a multiple suppurative arthritis. He died shortly after operation from shock and sepsis. At autopsy a pure culture of hæmolytic streptococcus was obtained from the heart's blood.

Tetanus.—No other infection of any moment was encountered in this series other than tetanus. As will be brought out under Mortality, the late deaths were almost all due to streptococæmia, the terminal event

being a bronchopneumonia, a septic embolus, or visceral degeneration from sepsis. There were 3 cases of tetanus, 2 fatal, 1 recovering.

The first (Case 53) died on the seventeenth day following a resection of the head and neck of the femur for a compound comminuted fracture of the neck caused by shell. This case was complicated by the presence of a gas gangrene at the time of the first operation, seventeen and one-half hours after injury. He received 1500 units of antitoxin at the time of injury, but as far as can be determined no further antitoxin until the time of onset of symptoms of tetanus, two days before death. At autopsy no cause of death other than tetanus was found.

The second case (Case 104) was received four days after injury, having been primarily operated upon at a field hospital twenty-four hours after injury. He was not reoperated after admission, was treated mechanically for his fracture, and ran a normal temperature for forty-six days. His temperature then rose and symptoms of tetanus appeared. On the forty-second day his wound showed a culture of *bacillus aërogenes capsulatus* and on the sixty-fifth day he showed a positive streptococcus blood culture. On the sixty-sixth day he died, still with a trismus and spasms of the injured leg despite enormous doses of antitoxin. No operative procedure was done. He should have been amputated at the first symptoms of tetanus. At autopsy a multiple suppurative arthritis and a terminal bronchopneumonia were found.

The third case (Case 122) was that of a major admitted one hundred and thirty-six days after having received a compound fracture of the lower third of the femur by shell. He was transferred to our service, a distance of over 100 kilometres by ambulance, and on the day following admission showed a definite trismus and twitching of the injured leg. He had primarily been operated on at a field hospital on the day of injury. As far as could be ascertained, no further operative procedure had been carried out. On admission position was extremely poor. There was no union and terminal exposed sequestræ were evident in an open wound. He was given 100,000 units of antitoxin during the first three days, and then an average of about 10,000 units a day for ten days. On the one hundred and fortieth day a sequestrectomy was done. By the one hundred and fiftieth day symptoms of tetanus had disappeared. On the one hundred and sixty-sixth day because of toxæmia and anatomical loss through suppuration he was amputated and went on to complete recovery. Tetanus was in this case activated by ill-advised transportation.

Complications.—Other than those already described as the result of infection, the complications were relatively few. There were very few cases of decubital gangrene, and with the exception of one case all occurred in late cases of sepsis. Despite the number of streptococcus infections, there were no cases of true erysipelas. There were 2 cases of lobar pneumonia (1.7 per cent.), one recovering and the other (a negro) quickly succumbing. All other cases were of the bronchopneumonic type

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and occurred during the terminal stages of a streptococcus sepsis. There was one severe secondary hemorrhage from an unamputated leg with gas infection. One amputated case required religation on the twentieth day. One case developed diphtheria on the thirteenth day.

TREATMENT

The primary operative work done on these cases is unquestionably the most important part of their treatment, for thereon depends frequently not only life and the conservation of the limb, but also its ultimate function. On the operative treatment first carried out also depends not only the early anaërobic and severe streptococcus infection, but also the late chronic infection so frequently seen in the form of osteomyelitis and long slow sequestration. This work should not only be done at the earliest moment after injury, but should be carried out by the best surgeons a country can send to its fighting men. The later treatment of these cases can be left to the care of less experienced men working under proper guidance.

To decide whether in a given case of fracture of the femur the case is non-operative or operative, and, if the latter, what the type of operative procedure shall be, is, in the opinion of the writer, as difficult a problem as exists in the realm of surgery. Previous to the statistical study of this series of cases and possibly stimulated by certain adverse criticism, we had felt that perhaps we had been too radical in our treatment. Now that the analysis has been made and the group studied in retrospect, we are convinced that our main error in treatment lay on the side of conservatism. We feel at least that our mortality rate would have been considerably lower if we had not so steadily persevered in our effort to conserve limbs.

We will first summarize briefly the operative treatment to which these cases were subjected, apologizing for a certain admixture of autopsy findings which we feel we must quote at this time for purposes of clarity. We will study the cases in groups, first taking up the injuries caused by the two main types of missile and then considering the injuries according to the location of the fracture.

BULLET FRACTURES

As before noted, there were 65 cases of fracture by bullets. Of these, 16 were kept under observation without operation. Of the 16, 12 healed by primary union (18 per cent.) and remained clean. Two cases developed abscesses which were opened on the twenty-fourth and sixty-third days, respectively. Both went on to complete recovery without further operative treatment. The two other cases developed abscesses on their seventeenth and thirty-seventh days, respectively, and both died of a general hæmolytic streptococæmia, the organisms being recovered from

the blood stream before death in one case and at autopsy from the heart's blood in the other. Both of these cases should have been amputated, as one (Case 47) did not die until the fifty-eighth day, and the other (Case 40) not until the fortieth, although the fatal outcome was entirely unexpected at the time when amputation would have been of value.

Nine cases were operated upon at the first opportunity, either by us or at a field or evacuation hospital. A double conical débridement was the usual procedure. Intact or nearly intact missiles were removed, lead "splatterings," such as shown in Fig. 2, were not usually sought. All of these cases recovered without further operation.

Eleven cases were similarly operated and differed from the 9 just mentioned only in the fact that late sequestrectomies were necessary.

One unoperated case was admitted on the third day with advanced gas gangrene. An immediate sausage amputation was done. This patient died on the nineteenth day with a positive hæmolytic streptococcus blood culture. At autopsy no sign of an active anaërobic infection was found.

Five cases were operated upon immediately on admission, were re-operated within a few days without amputation for spreading infection, and recovered.

Three cases were operated upon immediately and shortly thereafter were amputated for spreading infection. All recovered.

As against these last 8 cases, we wish to especially call attention to 9 cases which were operated upon at the first opportunity, *none of them being immediately amputated and all dying*, from what in retrospect we now consider to have been poor surgical judgment due to conservatism. These cases are sufficiently instructive to detail them briefly.

CASE 16.—This man was admitted thirty-six hours after injury, not previously operated, with an extensively comminuted femur and a marked gas gangrene. His wound was twice débrided. *He was never amputated.* Death on twelfth day. *Autopsy showed no cause of death other than an extensive gas gangrene of the thigh.*

CASE 21.—Almost identical with Case 16. Was three times operated but *never amputated.* At autopsy no definite findings other than a *progressive gas gangrene of the thigh.*

CASE 23.—First débrided in our service two days after injury. Rather chronically septic during entire stay in hospital. On fifty-fifth day an extensive sequestrectomy was done, followed by death six days later. Autopsy showed an acute rapidly spreading gas gangrene of the thigh. This was suspected the day after sequestrectomy, yet this patient was allowed to go on to death without amputation.

CASE 25.—Became septic on fifteenth day. *Never amputated,* although death did not take place until the forty-eighth day.

CASE 41.—Not amputated until eighteenth day. Autopsy showed *only a progressive gangrene of the stump.*

SYNOPSIS OF 131 CASES OF GUNSHOT FRACTURE OF THE FEMUR TREATED A

Serial number	Admitted	Side involved	Situation	Etiology	First operation	Second operation	Third operation	Fourth operation	Amputation	Resection	Disarticulation	Gas	Ice tong, long traction			Steinman pin traction			Associated lesions	Complications
													Inserted	Removed	Reason	Reason	Removed	Reason		
91	4	R	U	Auto	1															
92	5	R	M	S	1															
93	1	L	L	B	1	10	18	43					37	65	Union					
94	16	L	L	S	1	39			39											F.C.C. tibia.
95	21	L	M	B	?	34														
96	5	R	L	S	1															G.S.W. multiple soft parts.
97	40	R	L	S	2	66														F.C.C. elbow. Resection of elbow
98	46	L	L	S	1															
99	1	R	M	B	1	26														
100	5	R	L	S	2	8	9		9			Yes				12	48	Union		
101	3	R	L	B	2	3	24	67												
102	5	L	L	B	1	5	20		5			Yes								G.S.W. testicle. F.C.C. tibia. Division posterior tibial artery
103	46	L	L	S	1	57			57											
104	46	L	N	B	1	25				25										F.C.C. radius and ulna.
105	3	L	N	B	1	18	25	53	53	18										Lobar pneumonia
106	3	R	M	S	1	3										3	48	Union		
107	3	L	L	S	1	3										3	54	Union		F.C.C. radius. G.S.W. multiple soft parts
108	4	L	U	S	1	4		4			Yes									G.S.W. multiple soft parts with gas calf
109	7	R	U	S	1	7		7		7	Yes									
110	3	L	U	B	3	16	18		18				3	18	Amputated					
111	4	R	M	B									4	51	Union					
112	2	R	M	S	4								2	4	See remarks					
113	4	L	M	S	4								4	15	Death					Lobar pneumonia
114	49	R	M	Fall	1	52							52	77	See remarks					Mal-union
115	2	L	L	B	2											2	55	Union		F.C.C. metacarpal requiring amputation. G.S.W. R. knee joint
116	5	L	M	S	1	10	20	64												Acute rheumatism
117	7	L	L	B	1															
118	8	L	M	B	1	63														
119	2	L	U	B	5				5		30	Yes	2	5	Amputated					
120	18	R	L	B	1	90														
121	9	L	U	B																
122	3	L	L	B																
123	8	L	L	B	1	8	9		9			Yes				8	9	Amputated		Divided sciatic. F.C.C. metacarpal
124	8	L	M	B	1	63														
125	4	R	L	B									4	48	Union					
126	8	L	M	B	1								8	28	See remarks					
127	63	R	L	B	1															
128	16	L	U	B	1															
129	41	L	L	S	1	58														
130	136	R	L	S	1	140	166		166											Tetanus
131	37	R	M	B									41	49	Slight infection					

NOTES.—All figures refer to number of days after injury. Under bacteriology, "H.S." refers to the hæmolytic streptococcus. "Bac." to the bacillus aerogenes capsulatus. arranged serially as far as possible under the date of admission to Hospital. Under "Situation," "N" refers to neck of femur, "U" to upper third, "M" to middle third, and "L" to lower third.

TREATED AT THE AMERICAN RED CROSS HOSPITAL, 2, PARIS—Continued

Complications	Blood culture	Wound culture	Evacuated	Remarks
		Simple fracture	70	Slow union with some tendency to bowing.
		20, 26, H.S.; 33, neg.; 43, 47, H.S.	83	Beginning union 55. Solid 75.
		55, 61, H.S.		
	41, neg.	14, neg.; 23, H.S.; 38, 51, H.S.	76	Good union 65. Tongs applied because of blisters from glued bands.
	50, 57, 64, H.S.	24, neg.; 52, 59, H.S.; 72, neg.		Sudden death. Autopsy failed to show embolus. Marked myocardial degeneration. No suppurative joints. Hemolytic streptococcus from heart blood.
		30, neg.	53	
		5, 13, Bac.; 14, 37, 41, neg.	77	Beginning union 43. Solid 63.
	71, H.S.	2, H.S.; 54, neg.; 60, H.S.		Wire loop suspension by French. Sepsis did not start until after sequestrectomy on 66th day. Progression very rapid following.
		61, neg.; 67, Bac.	70	Wire loop suspension by French with plaster cast. Good result. Union fairly solid on admission.
		17, neg.; 23, H.S.; 33, 37, 51, neg.	72	Beginning union 40. Solid 60.
		3, 57, neg.	81	Multiple streptococcus sepsis. Partial thrombosis femoral vein. Empyema. Oblique fracture difficult to control. Circular wire at second operation. Later removed.
		5, 6, neg.	36	Amputated for gas calf and suppurative arthritis of knee. Religation femoral artery on 20th day for secondary hemorrhage.
		2, H.S.	77	Amputated for anatomical loss. Very wide resection had been done at French Hospital. Uncomplicated after amputation. Should have been primarily amputated to save time. Primary wire loop suspension.
bar pneumonia	26, H.S.; 39, neg.	61, 67, 78, neg.; 95, H.S.	225	General streptococemia. Knee-joint involved, not by direct extension.
		3, neg.; 9, 15, H.S.; 26, 30, 37, neg.		Suppurative pericarditis at autopsy.
		45, 49, H.S.	67	Solid 48. Wound healed 67.
		3, neg.; 23, 31, 38, 46, H.S.	67	
		8, 17, neg.; 23, 38, 46, 53, H.S.		
		4, Bac.; 6, neg.	24	
				Amputated for gas and extensive osteomyelitis with great splitting. Disarticulation immediately done. Died in 2 hours of shock.
		Primary union	52	Purulent knee and wrist. Died 10 hours after operation.
		Primary union	99	Beginning union 35. Solid 50. Bullet left in situ.
bar pneumonia		4, Bac. and H.S.; 5, Bac.; 6, Bac. and H.S.		Really a simple fracture. Fractured by air concussion with only slight skin tear. Fracture transverse. Lack of apposition in both planes equal to diameter of shaft of bone, persisting after 2 days of heavy tong traction.
al-union		45, H.S.		Open reduction and Lane plate on 4th day. Perfect result.
			139	Died of a massive pneumococcus lobar pneumonia. Pneumococcus, Group 2, in sputum.
	15, neg.	Primary union		Admitted in very poor position with beginning union and much over-riding. Very pretty result obtained with tongs. High aeroplane fall, compound fracture.
ute rheumatism	33, neg.	5, 20, 30, H.S.; 36, 45, neg.	81	Fracture of femur by contre coup. Bad infection of hand.
		14, H.S.	109	
		11, 16, 24, Bac. and H.S.; 56, H.S.	79	Good result with glued traction. Solid in 3 weeks.
	12, neg.	92, H.S.	95	
			93	Very septic. Recovery unexpected. Very extensive comminution.
		Primary union	105	Closed tight at primary operation. No union at end of 90 days. Then reoperated and interposed muscle removed. Wound infected and opened 92.
		Primary union	96	Beginning union 40. Solid 58.
	32, neg.	8, Bac. and H.S.	90	Out of splint 53. Can put weight on leg 68.
			95	
		64, 75, H.S.	95	
	54, neg.	Primary union	91	
			95	
		19, 38, neg.	135	
		44, 69, H.S.	82	
tanus		140, neg.; 146, H.S.; 180, H.S.; 185, Bac.; 195, H.S.	107	Developed a suppurative knee from direct extension of infection, following sequestrectomy. Hemolytic streptococcus from knee-joint. Recovered with drainage.
		Primary union	193	Tetanus developed immediately on admission following long and ill-advised transportation. Admitted with large terminal sequestræ. No union. Profuse suppuration. See text under "Tetanus."
			88	

nes capsulatus. "Neg." does not mean that the culture was necessarily sterile. It implies neither of the above mentioned organisms was present. The cases have been third, and "L" to lower third. Under "Etiology," "B" refers to a rifle or machine-gun bullet to a shell fragment.

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CASE 71.—This patient on his twentieth day became septic, but was not amputated until the eightieth day, far too late. He died of an avoidable streptococæmia.

CASE 80.—A fracture of the head and neck of the femur débrided only at an advance hospital. Also insufficiently cared for by us. He was admitted to our service on the fifteenth day, yet no resection was done until the fifty-fourth day and the patient was *never amputated*. He died of sepsis on the ninety-fourth day, having been septic for two months.

CASE 105.—Another fracture of the head and neck of the femur insufficiently operated "up the line," nineteen hours after injury, a simple drainage to the site of fracture and the hip-joint having been done. This patient was septic almost from the time of admission to our service, but was not resected until the eighteenth day. Wound constantly showed a hæmolytic streptococcus. After resection he remained septic with a positive hæmolytic streptococcus blood culture on the twenty-sixth day. He was not amputated through the hip-joint until the fifty-third day, far too late, with the inevitable result of almost immediate death. This man, as we will attempt to show later, should have been primarily amputated.

CASE 110.—A negro with an extensively comminuted upper third fracture not admitted until three days after injury, the fracture on admission badly infected. Should have been amputated immediately for anatomical reasons if for no other. Became septic and was not amputated until eighteenth day. Died shortly after operation from shock.

SHELL FRACTURES

We will briefly summarize in a similar way the cases wounded by shell. There are 48 such cases. All were operated upon.

In one case for some inexplicable reason a shell fragment was removed, no extensive débridement was done, the wound was closed without drainage and healed primarily. Unfortunately the data on this case are incomplete. We are inclined to believe that the fracture was caused by air concussion and that the shell fragment lay superficially. We do not in any way sanction this form of treatment.

In 10 cases the patient was operated upon at the first opportunity, no further operation was necessary, and recovery followed. Fifteen other cases differed from these 10 only in the fact that one or more late sequestrectomies were necessary.

Five cases were amputated immediately on admission, all for a complicating gas gangrene. Of these, 4 recovered and 1 died. The death occurred during a period of extreme activity in a patient who had been operated at an advance hospital twenty-four hours after injury and had apparently been untouched from that time until admission to our service, seven days later. On admission he was already practically moribund, with a late stage of gas gangrene extending from the umbilicus to the foot. He died almost immediately after operation.

Five cases were operated immediately on admission, were later amputated, and recovered. All of these cases might better have been primarily amputated, as, with the exception of one case, all required amputation rather shortly after their first operation.

One case, a negro, died on his fifteenth day from a lobar pneumonia involving the right middle and lower lobes. The condition of the leg was satisfactory at the time of death.

We will once again itemize the deaths which we consider should have been avoidable. All of them can be laid at the door of conservatism.

CASE 14.—Admitted thirty-six hours after injury with gas thigh. Débrided only. Similarly operated two days later. Not amputated until sixth day when nearly moribund. Autopsy showed *nothing but an extensive gas gangrene of the stump*.

CASE 34.—Operation on day of injury at an advance hospital. Admitted on eighth day with evident gas. Débrided only. Not amputated until eleventh day. Died on sixteenth day. Autopsy showed *nothing but a gas gangrene localized to the stump*.

CASE 36.—Previously operated. Reoperated twice but not amputated until seventieth day, although sepsis had been severe for weeks with a marked acetonuria and constant vomiting. Autopsy showed the usual findings of a hæmolytic streptococcus bacteriæmia. Amputation was suggested many times in this patient but always deferred because of temporary improvement. He could have been easily saved.

CASE 38.—No previous operation. Admitted on second day with gas. Débrided only. Reoperated on third day. *Never amputated*. Died on fifth day. Autopsy showed an extensive gas gangrene *limited to the thigh*.

CASE 50.—Admitted with gas and débrided forty-eight hours after injury. Did well for eight days. Then sudden spreading of gas gangrene. Was not amputated and died on following (eleventh) day.

CASE 53.—A fracture of the neck of the femur admitted eighteen hours after injury with gas. Débrided only. Resected on eighth day. Should have been amputated (see discussion of these cases later). Died on seventeenth day of tetanus.

CASE 76.—Operated upon at advance hospital on day of injury. Admitted four days after injury. *Never reoperated*. Developed tetanus on forty-sixth day and died on sixty-sixth. Should have been amputated at first symptom of tetanus as there was no union and supuration was profuse.

CASE 88.—Another fracture of the neck of the femur, not resected until the thirtieth day and not amputated until thirty-fifth day. Died on forty-first day. Should have been amputated primarily. (See discussion later.)

CASE 94.—A low fracture with splitting into the knee-joint with profuse suppuration which also involved the joint. Was not amputated until thirty-ninth day and died on the seventy-seventh. Should have been amputated early.

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CASE 100.—Admitted on ninth day, having been previously operated on second day. Knee-joint had been penetrated and sutured tight. Immediately opened and streptococcus pus obtained. Not amputated until ninth day, when an unsuspected gas gangrene limited to the vastus internus and spreading up the sciatic sheath was found. Died on eighteenth day. Amputation delayed too long. Gas should have been recognized.

As before noted, the primary operative decision in cases of compound fracture of the femur is difficult. In this series the error has undoubtedly lain on the side of conservatism. Débridements were not sufficiently extensive nor were a sufficient number of primary amputations done. We have just called attention to 19 cases, every one of which should have been more radically treated and the majority of which could have probably been saved. Eliminating the 12 cases of bullet fractures which healed by primary union without operation and remained clean, the incidence of infection, both aërobic and anaërobic, has been about the same in fractures caused by the two types of missile. The primary operative treatment should therefore in the main be similar. Incisions should be sufficiently large to allow complete exposure and dissection of the missile tract. They should be made, when possible, in the long axis of the limb. In the case of perforating wounds it is often wise to make the incisions on either side of the limb, the dissections being then deepened to meet each other in the form of a double conical débridement. All involved tissue, especially muscle tissue, should be carefully dissected and removed. Clothing is particularly dangerous and should be carefully sought for. Personally we prefer a knife to scissors for this work, as we feel that cleaner and more exact dissection can be done. Lead splatterings, as before mentioned, are usually not sought, as experience has shown that they are apt to be innocuous. Larger bullet fragments are removed and shell fragments invariably unless of extremely small size. Loose completely separated fragments of bone buried in muscle are felt for and removed. Otherwise bone is removed only if grossly soiled and to a sufficient degree to insure free drainage of the marrow cavity. It is well to remove such fragments posteriorly rather than laterally, if possible, in order to provide dependent cavity drainage. This bone removal must be done with great care, if due regard is to be had for the resulting union. It has been our practice to remove all such fragments subperiosteally, using for this purpose the set of cutting periosteal elevators devised by Ollier. Important structures, such as nerves and blood-vessels, should be dissected free and if possible preserved. Muscle anaërobically infected must be removed if the infection has progressed beyond the stage of œdema, and this removal must continue until muscle of normal color and appearance is encountered, muscle which bleeds readily when cut and reacts quickly to mechanical stimulation. At times this removal seems

brutal and unjustified, as, for instance, when the entire rectus femoris, sartorius, or one or more of the hamstrings is dissected from origin to insertion. But it is a procedure which must be carried out in order to obviate the necessity of amputation or be forced to face the alternative, death. Muscles showing œdema only will frequently recover with simple multiple ribboning of the sheath.

In certain cases, because of the obliquity and situation of the fracture, mechanical fixation of the fragments has seemed wise. In this series, mechanical fixation was used in 5 open cases. In 3 cases wire loop suspension of each fragment with the application of plaster of Paris was used by a French surgeon previous to admission to our service. In 2 cases we removed the wire on the fortieth and sixty-sixth days, respectively. In the third case a very wide resection had been done—apparently not subperiosteally, as there was no sign of new bone at the end of fifty-seven days—and the case was amputated by us on the fifty-eighth day. In two fresh cases we threw circular bronze wire about long oblique fractures at the primary operation as a temporary measure, removing the wire on the sixty-seventh day in one case. In the other case, because of sepsis, amputation was necessary on the thirty-fifth day. With improved methods in mechanical suspension and traction for these cases, we feel that direct mechanical fixation of bony fragments is rarely justified in gun-shot cases.

FRACTURES INVOLVING THE HIP-JOINT

The problem involved in these cases is somewhat different from fractures involving the shaft alone and merits a brief consideration. In our experience all gun-shot fractures, not only of the head but also of the neck of the femur, even of its base, involve the hip-joint. Let us first briefly detail and analyze the 7 cases which occurred in this series. They are discouraging.

CASE 32.—A fracture through the base of the neck by shrapnel ball. Débridement of the soft parts and drainage of the hip-joint forty hours after injury. Resection of the head and neck on the twenty-first day. Evacuated to the south of France on one hundred and twelfth day. Sinus still open. Patient still bed-ridden. No union.

CASE 53.—A fracture of the middle of the neck by shell. Gas present on admission. Débrided seventeen hours after injury with removal of loose bone fragments. Profuse suppuration. Resection of head and neck on eighth day. Developed tetanus and died on seventeenth day.

CASE 77.—A fracture of the base of the neck by machine-gun bullet. Débridement twenty hours after injury. Frequent incisions for abscesses up to forty-third day when resection of head and neck

FRACTURE OF THE FEMUR

was done. Developed a dissecting hour-glass abscess which travelled behind the femoral vessels and pocketed extraperitoneally in the false pelvis. After repeated operations for secondary drainage, he was evacuated to the south of France on his one hundred and eightieth day, with sinus still open, practically no union at the hip, and still bed-ridden.

CASE 88.—A fracture of the base of the neck by shell. Débrided twenty-four hours after injury. Resection of head and neck on thirtieth day. Became septic. Amputated through hip on thirty-fifth day and died of sepsis on forty-first day.

CASE 94.—A fracture of the base and shaft of the neck by sniper's rifle ball. Débridement twenty-four hours after injury. Resection of head and neck on fifty-fourth day. This patient ran a stormy and unhappy course, with repeated operations for secondary pockets, until death occurred on the ninety-fourth day from chronic sepsis and exhaustion.

CASE 104.—A fracture of the head and neck of the femur by machine-gun bullet. Débrided on first day. Resection of head and neck on twenty-fifth day. Ran a long course and was finally evacuated to the south of France on the two hundred and twenty-fifth day, still bed-ridden, sinuses still open.

CASE 105.—A fracture of the base of the neck by machine-gun bullet. Débrided nineteen hours after injury. Resection of head and neck on eighteenth day. Septic. Amputation through hip on fifty-third day. Almost immediate death from shock.

We feel that the treatment of every one of these cases was faulty. Their death rate was over 57 per cent. as against a death rate of 19.8 per cent. for the entire series. The cases which "recovered" were pitiful in their far from end result. Their period of hospitalization and convalescence was destined to include a very appreciable amount of the years allotted for life, and during this period they promised to be very constant sufferers. While we had no immediate operative mortality in the series, the operation of resection of the hip-joint is not an easy one. If done by the posterior incision, the external rotators are divided to such an extent that it is practically impossible to prevent the amputated end of the femur from riding up on the iliac flare. If done through the anterior incision, posterior stab-wound drainage which will not stay open must be provided, and constant pocketing occurs. How much easier it would be for both patient and operator to perform an immediate amputation through the site of fracture, waiting for ten days to remove the head and neck. With this the mortality rate should fall to about zero and months, if not years, of convalescence would be saved, with an end result which personally we would far prefer to those we have seen in late adult hip resections months and years after operation.

BULKLEY AND SINCLAIR

FRACTURES INVOLVING THE KNEE-JOINT

The fractures of the lower third of the femur which involve the knee-joint are also deserving of a brief word. We will omit the discussion of those cases in which the knee-joint of the involved side is penetrated by a second missile, or of those cases of penetrating or perforating wound of the knee in which there is an associated fracture of an articular surface or of a condyle only of the femur. We speak particularly of those fractures of the lower third of the femoral shaft in which there is a direct splitting into the joint. Attention has already been called to the fact that this fissure may be very small and of such a sinuous course that it may at first be easily overlooked in the course of a routine X-ray examination. But even so, it serves as a potential course for the direct extension of infection from the main site of fracture to the cavity of the knee-joint. Of 41 cases of fracture of the lower third of the femur, such a splitting occurred or was recognized 12 times. Seven were treated, as far as the knee-joint was concerned, expectantly. One healed cleanly without infection, an unoperated bullet case. Six suppurated. Of these, 5 eventually resulted in amputation. In the sixth case the joint recovered with drainage. Of the remaining 5 cases, 2 were treated by the aspiration of a clean hæmarthrosis and recovered without infection. One was amputated immediately on admission for extensive anatomical loss and division of the posterior tibial artery; 1 was amputated immediately for an extensive gas gangrene; and the other primarily resected and later amputated for infection. Thus of 12 cases of fracture of the lower third of the femur with splitting into the knee-joint, 8 sooner or later required amputation. This result is not good, yet we hardly know what suggestions to make to improve the prognosis of this injury. We feel most pessimistic regarding wounds of the knee-joint associated with bony injury. In our experience with a considerable number of cases not included in this series of wounds of the knee-joint associated with bone injury, either resection or amputation has eventually been necessary.

AMPUTATIONS

No discussion of the treatment of compound fracture of the femur can be complete without reference to amputation. In this series we amputated sooner or later 30 cases, about 23 per cent. of the compound fractures. The percentage is high, but as we shall presently show, should have been higher. The cases were amputated for the following reasons: For gas gangrene, 16; for severe secondary hemorrhage, 2; for anatomical loss, 2; for sepsis, 9; for osteomyelitis, 1. Practically all the gas gangrenes were neglected unoperated cases. Many were far advanced. In many the bony injury was extensive. The 2 cases amputated for anatomical loss had both been previously resected. Both might have better been pri-

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marily amputated, as the initial loss was over 4 inches. The cases of sepsis varied from patients with legs which were masses of dissecting pus pockets to patients with suppurative knee-joints or generalized streptococcus sepsis. The patient with osteomyelitis was amputated for that alone. In both cases of severe secondary hemorrhage, gas gangrene was present.

The mortality rate of the cases amputated before the fourteenth day before they became chronically septic was 33 per cent. The mortality rate of those cases amputated later was 50 per cent. The rate for the entire 30 cases of amputation was 40 per cent. The earlier the amputation the lower the mortality rate. After a certain period of prolonged sepsis amputation is not well tolerated.

These cases are all sick. Amputation should be rapid. Team work is essential. Our practice has been to make a long anterior and short posterior flap, amputating by transfixion. The amputation may be done through the site of fracture, the large vessels secured, and then with the aid of the Percy saucer retractor the bone can be divided above the level of fissures. This has appealed to us as the quickest and best method, for if the patient does not react well, the division of bone can be postponed until proper reaction has set in some days later. If possible, however, it is better to divide the femur above the line of fissures at the primary amputation, as by so doing much infected material is removed. If the patient is still in good condition, all muscles (in gas gangrene cases) are then dissected upward and removed until healthy tissue is reached. The sciatic is drawn well out of its sheath and divided with a sharp knife. We have watched particularly for shock during this procedure and have failed to observe it. Consequently we no longer locally anæsthetize the nerve before division. The main vessels are doubly ligated with No. 2 plain gut. We have had no cases of secondary hemorrhage following this procedure. The wound is left practically unsutured, but the anterior flap is never under any circumstances turned back and sutured to the skin of the anterior thigh. We believe that sufficient gravity drainage is obtained if this flap is allowed to fall over the stump and that the exposure of the stump with the flap sutured back is distinctly disadvantageous.

For the control of hemorrhage during amputation we use a rubber tourniquet. The Esmarch bandage is prohibited because of infection. In high amputations because of the danger of the slipping of a tourniquet, we depend on manual pressure on the femoral vessels just above Poupart's ligament by a non-sterile assistant.

Most of the high amputations just below the anterior intertrochanteric line later need disarticulation because of the distressing constant flexion, abduction, and external rotation. It is not a difficult operation or one attended by shock. It should be done by an external incision about ten days to two weeks after amputation before too much cicatrization has occurred.

"CLEAN" OPERATIVE TREATMENT

In 3 cases of the series—I simple fracture by motor-cycle accident and 2 compound fractures by machine-gun bullets—operation was undertaken solely for the mechanical reduction and fixation of the fragments.

The first case (Case 30, motor-cycle) was admitted within two hours after injury with a transverse fracture of the mid-femur. Within three hours after injury a Lane plate had been inserted. Recovery was perfect and uneventful. It was interesting how easy it was to reduce and hold this fracture for plating. It could almost be done without assistance. This patient was treated by suspension and only 5 pounds traction for "steady" purposes, and motion at the knee was encouraged from the beginning. He was never immobilized and was evacuated walking on his seventy-seventh day with a practically perfectly functioning knee. The lack of plaster immobilization seemed to cause no tendency for loosening of the screws. He was seen following evacuation for a period of a number of months, on a duty status, having no further trouble. His plate was never removed.

The second case (Case 112) was that of a negro admitted two days after injury with a transverse fracture of the femur caused by the passage of a machine-gun bullet. There was no indication for operative interference, the leg was clean, and ice-tong femoral traction was immediately applied. Bed-side radiographs (Figs. 3 and 4) after thirty-six hours of heavy traction showed no overriding but displacement in both planes equal to the width of the femoral shaft, a finding pathognomonic of muscle interposition. Accordingly on his fourth day the tongs were removed, open reduction was done, interposed muscle was released, and the fracture Lane-plated. This patient was also suspended, no plaster was used, and convalescence was normal. The reduction is shown in Fig. 5. He was evacuated on the ninety-ninth day.

The third case (Case 42) was admitted two days after injury, having received an irregular fracture of the lower third of the femur by rifle-ball of such a form that the lower end of the femoral shaft was displaced from a triangular bed between the condyles to the inner side of the inner condyle. There was no infection and the patient was not operated. Glued traction after attempted manipulative closed reduction was first tried without success. On the eighth day tong traction was applied. As after five days of powerful traction it was found impossible to reduce and hold this fracture, an open operative reduction was done on the thirteenth day with some difficulty, the tongs being left *in situ*. To maintain the fragments in place it was necessary to secure them by one chromic suture placed through drill holes. In this case a perfect anatomical and functional result was obtained. He was evacuated on the seventy-fifth day, union having been noted on the forty-eighth. Unfortunately the plates on this patient are not available.



FIG. 1.—Bullet hole just shows at lower edge of picture.



FIG. 2.—Showing spattering of missile fragments through the tissues.



FIG. 3.—Anterior-posterior view after tongs were applied and before plating.



FIG. 4.—Lateral view after tongs were applied and before plating.



FIG. 5.—After plating. Plate can be indistinctly seen.

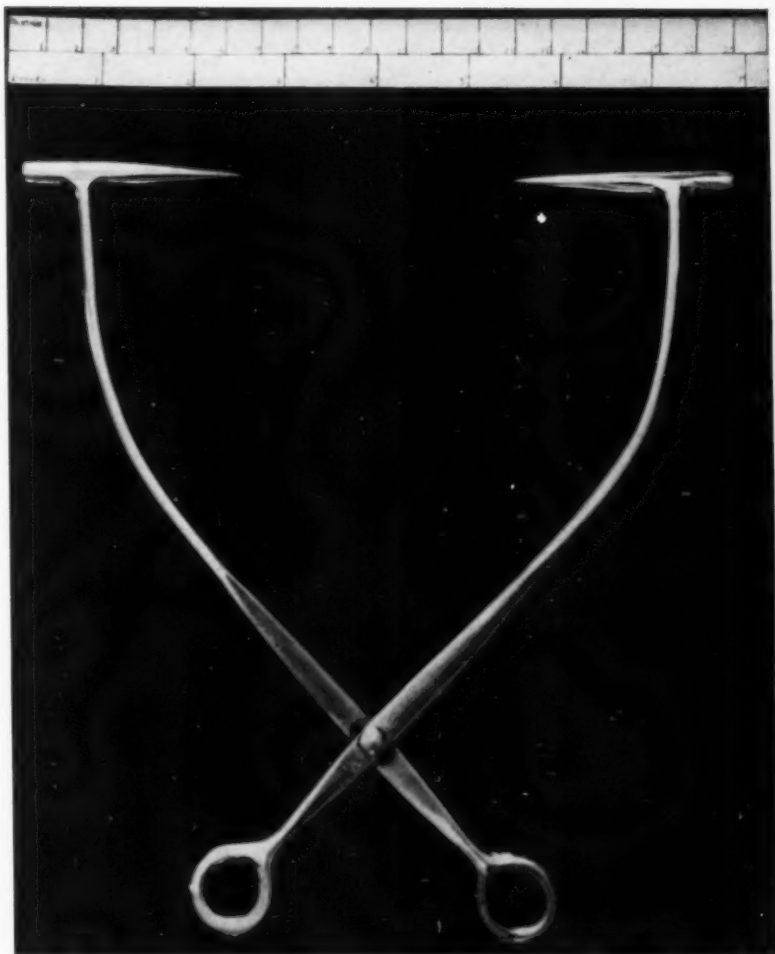
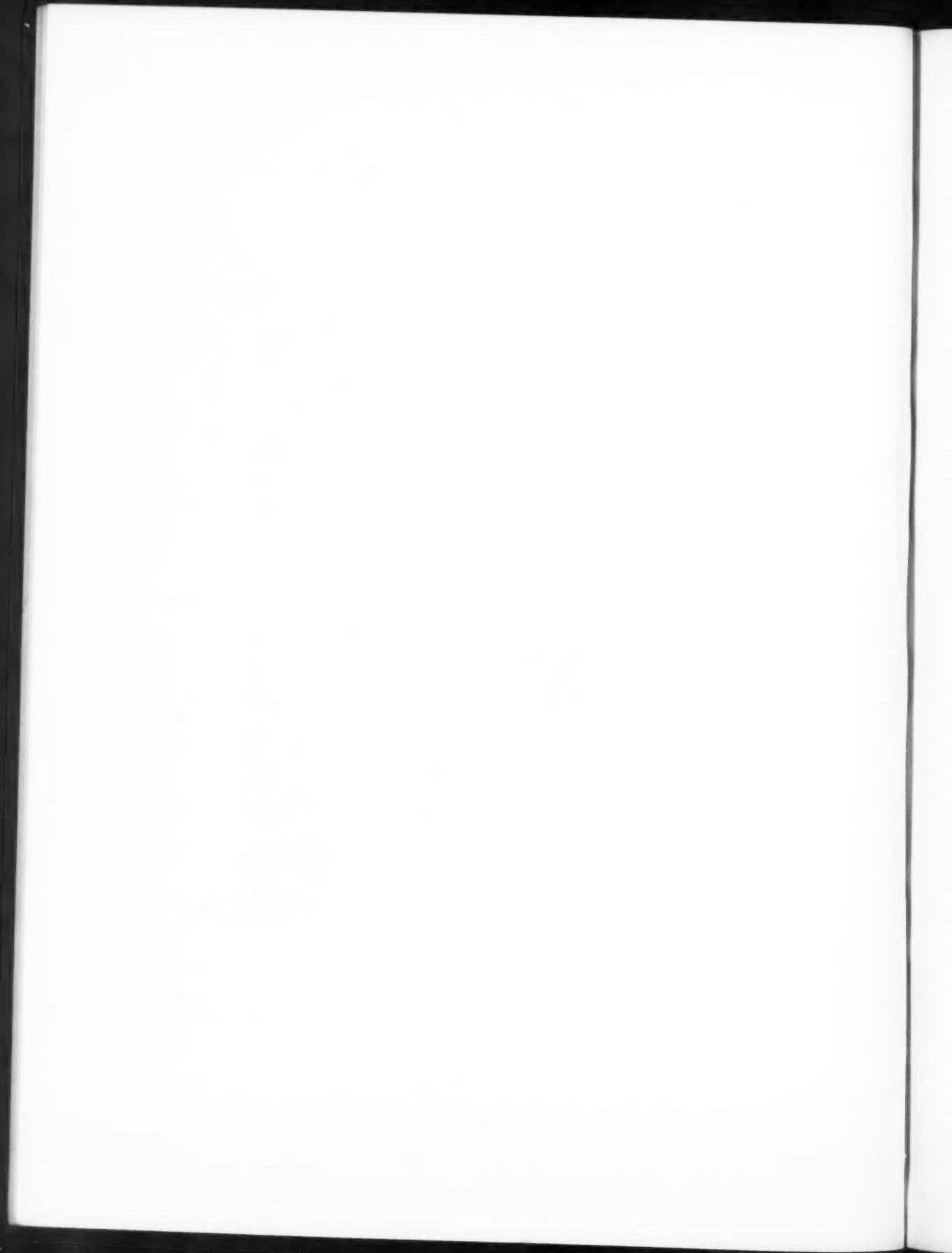


FIG. 6.—Traction tongs.



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TRACTION

In 57 cases skeletal traction was employed at some time during the period of treatment. In the remainder of the cases traction was made by glued bands, using either the Heussner or Sinclair type of glue. Our rule has been to apply heavy weight during the first few days and to then diminish it, a practice which is in direct contradiction to the old teaching which applied traction lightly at first with gradually increasing weight. We are convinced that shortening due to muscular contraction is more easily, quickly, and permanently controlled in this way than by the older method. In using glued bands, traction through a joint has as far as possible been eliminated by applying the bands above as well as below the level of the knee. In this way relaxation of the ligaments of the knee-joint—a most annoying complication which may exist for six months or more after union—has been largely avoided.

The ideal form of traction is skeletal, as less than half the weight is required, the control is absolute, the uncertainty of the amount of traction lost on skin and deep fascia is eliminated, and in our experience the patient is more comfortable. Where possible, this traction should be applied to the lower portion of the femur itself. At times, however, it is necessary to apply it through the ligaments of the knee-joint, using the tibia for this purpose. We have entirely discarded the use of the Finochetto or Chutro band (os calcis traction) for fracture of the femur, because of the superiority of other methods. It has been our rule to use femoral traction whenever the situation of the wound allowed, reserving tibial traction only for those cases in which the wound was situated so low on the thigh that infection of the traction wound from this source seemed possible. With the exception of two early cases of the series treated during the summer of 1917, in which we used Steinman pins through the lower femur, femoral traction has invariably been made with ice-tongs. Tibial traction has in all cases been made with a Steinman pin driven through the tibial shaft on a level with and just posterior to the tibial tuberosity. Of the two forms of traction, that applied to the femur is infinitely superior, as no pull is exerted on the ligaments of the knee-joint and the joint can be actively and passively used almost immediately after application, a point of great importance, not only in relation to the eventual function of the knee, but also in the nutrition of the affected thigh during the period when bony union is taking place.

A few words in regard to the form of tongs and the method of using them may be of interest. After using a number of different types, the ones shown in Fig. 6 were adopted as giving the best results. They were made at the United States Army Instrument Repair Shop, Paris, from designs submitted by us. The material used was tempered steel 8 mm. in diameter. The distance between points with horizontal bars parallel should be 7 cm., as it has been found that with the points embedded in the femur

for a quarter of an inch this inter-point distance almost invariably allows rotation without pain. It is important that the points are not too sharp, as otherwise there is a tendency for them to become embedded too deeply in the bone. By following this precaution, we have found it unnecessary to place between the handles of the instrument any device to prevent their approximation. Incidentally this elimination reduces the difficulty and expense of manufacture. The outward bowing of the two limbs of the tongs is essential, if motion at the knee-joint during their period of application is to be obtained.

The method of application has been to make a small stab wound on either side of the lower thigh, being careful to pull the skin first a trifle above the points at which the tongs are to grasp the femur. This stab wound passes to and through the periosteum, is vertical in direction, and should be of sufficient length so that after the application of the tongs there is no pressure of skin on metal. The tendency is to make this stab wound too short. In the absence of infection, it is this pressure which causes discomfort. The point of application should be on each side about one finger breadth in front of the hamstring tendon and should meet the femur just above the point of greatest prominence of each condyle. The points are driven home into the shaft a distance of a quarter inch, a characteristic sound being obtained when the required depth has been reached. After proper application there should be no difficulty encountered in raising and lowering the handles. With tongs of the dimensions above given, such difficulty indicates that a site too high on the femoral shaft has been chosen, the tong points thus approximating each other too closely, with a resulting lack of parallelism of the transverse bars. The small sterile dressing about the tong wounds is usually not disturbed until the removal of the tongs. Immediately after insertion the tong handles are tied together with a bit of bandage. Traction having been once applied, it has been our rule never to release it until the tongs are removed, not only for the sake of the fracture but also for the comfort of the patient. We have wholly discarded the use of Steinman pins for femoral traction.

For tibial traction the Steinman pin has been used. A stab wound is made on the inner surface of the leg on a level with and about three-quarters of an inch posterior to the tibial tubercle, the pin inserted and driven through the bone until it can be felt beneath the skin on the outer side of the leg. The skin over this point is then pulled slightly upward and the second stab wound made. Care should be taken that the pin is driven in at right angles to the tibial crest and, with the toes vertical, parallel to the table.

Skeletal traction can be applied with local anæsthesia, but a general anæsthetic is infinitely preferable. We have been in the habit of employing inhalation ethyl chloride, carrying out the entire procedure usually in the patient's bed without assistance and no further armamentarium than

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tincture of iodine, a scalpel, a hammer, and two sterile towels. With a general anæsthetic of short duration, such as ethyl chloride, the procedure requires but a few minutes, and at the same time the extent of traction and the angle of the splint needed to overcome the overriding and correct the deformity can be accurately determined. With more careful technic and more available time, even the slight amount of infection which has occurred in this series should be eliminated. Since using skeletal traction extensively, we have given up the use of the Hennequin band as being too difficult in application and cumbersome in control.

Of the 57 cases in which skeletal traction was employed, ice-tongs were applied in 39 cases to the femur; Steinman pins in 2 cases in the femur and 14 cases in the tibia; and in 2 cases tongs were first applied in the femur, were removed too early, further skeletal traction was found necessary, and Steinman pins were inserted in the tibia. There are thus in all 59 examples of skeletal traction in 57 patients. It is of interest to summarize the early results of this treatment.

There were 41 cases of ice-tong (caliper) traction. In 7 of these the tongs were removed before they had accomplished their purpose, the cause of removal being either amputation, the necessity of sudden evacuation, or death. The average time of traction in these cases was ten days. None were infected.

In 12 cases (29 per cent.) the tongs were removed because of infection or fear of infection about the point of application. This percentage at first sight seems rather high. As a matter of fact, there was but one *real* infection in the series, a man with a profusely suppurating compound femur who developed a hæmolytic streptococcus sepsis, was amputated and died. At autopsy pus could be expressed from a suppurative knee-joint through a tong hole. Even this was not a clear cut case attributable to tongs, as the joint was quite possibly metastatic and the tong hole infected from it. In the remaining 11 cases the crusting and slough which almost invariably are present to a certain extent seemed a little too great and the tongs were accordingly removed before they otherwise would have been. In none of these cases was there a serious infection, nor were there any resulting cases of osteomyelitis. There was not a case, with the exception of the one just mentioned, in which the question of the involvement of the knee-joint even arose. In these 12 cases a traction time averaging 21.25 days was obtained, a distinct gain.

In 22 cases the tongs were left *in situ* until it was felt that their purpose had been accomplished. The average number of days traction obtained in these cases was 34.86. On removal of the skeletal apparatus, traction was maintained either by glued bands or by an anklet. This change was never made until the traction weight could be safely reduced to a small amount, a reduction which could be made much earlier in the course of treatment as the result of heavy initial traction.

The experience with Steinman pins has been almost identical. In 27 per cent. of the cases the pin was removed earlier than it otherwise would have been because of infection or fear of infection. In none of these cases was the infection of any moment. There were no cases of osteomyelitis. The average traction time before removal was 30.20 days as compared with the remainder of the cases in which the traction time averaged 40.20 days.

The tongs are readily removed without anaesthesia and practically without discomfort. As the Steinman pin is rather apt to be a bit more painful, we have been in the habit of using a primary nitrous oxide anaesthesia for its removal.

We will cite two cases as illustrating what can be accomplished with skeletal traction where glued traction faithfully attempted has failed of its purpose.

The first case (Case 57) was admitted to our service nineteen days after injury with a badly comminuted fracture at the junction of the middle and lower thirds of the femur. He was treated in a slightly bent Thomas splint with glued traction until his ninety-sixth day. During this entire period there was a constant and increasing tendency to posterior bowing or "dishing." It was practically impossible to control by traction alone and could only be partially controlled by the use of an inverted saddle arrangement giving upward pressure directly on the upper end of the lower fragment. By the ninety-sixth day "dishing" could no longer be prevented. On that day his displacement was as shown in Fig. 8, lateral bedside exposure. Ice-tongs were inserted in the femur and at the end of four days his position was as shown in Fig. 9, practically perfect. It will be noted that no change was made in the angle of the splint at the knee. At the end of four days tong traction was replaced by glued traction which maintained without difficulty the position attained by the use of tongs.

Case 114 is even more striking. This fracture, practically a transverse one of the mid-third of the femur, occurred in a well-known aviator from a fall. The fracture was compound. He was admitted to and operated upon in a French hospital, where he remained for forty-nine days before being admitted to our service. There was never any lateral displacement, his position as shown in an antero-posterior plate practically always remaining as shown in Fig. 10. His antero-posterior displacement was, however, marked, Fig. 11, taken on admission, showing a displacement equal to the diameter of the shaft. Ice-tongs were immediately inserted in the femur and after three days his position had improved to the extent shown in Fig. 12. Unfortunately, the remainder of the series of plates on this patient are not available. The end result in this patient was practically perfect, there being on consolidation possibly a trifle too much anterior bowing, a position infinitely to be desired to that of a "dished" united femur.



FIG. 7.—Before the use of tongs.



FIG. 8.—After application of tongs, and before lost sequestrectomy.



FIG. 9.—Anterior-posterior view. Never any change.

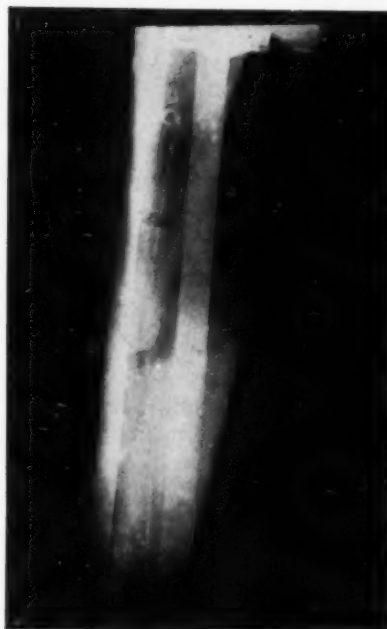


FIG. 10.—On admission.



FIG. 11.—Same as fig. 10, after tongs were applied for two or three days.

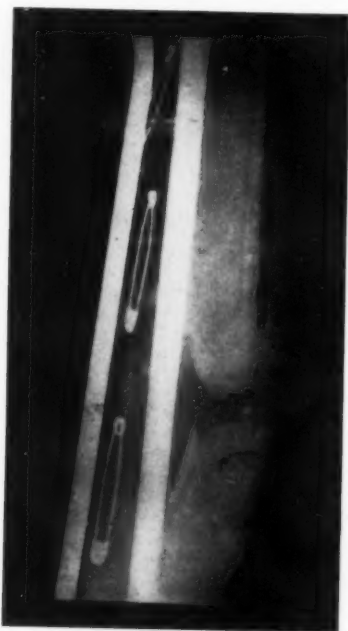


FIG. 12.—Same as fig. 10, after a long application of tongs.

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SUSPENSION

With the exception of an occasional case received in plaster of Paris—always from a French hospital—and rapidly evacuated because of his good condition and the rush of work, all of the cases of this series have been treated by suspension and traction. For definitive treatment we still prefer in the majority of cases the full-ring Thomas splint, reserving the Hodgen (anterior) type of splint only for those cases having high posterior wounds not readily adapting themselves to the pressure of the Thomas ring. The half-ring hinged Thomas (Blake-Keller), while admirably adapted to transportation, has not proved satisfactory for bed treatment because of its constant tendency to ride upward on the buttock. No description of the details of the mechanical suspension and treatment of these cases will be given, the reader being referred to previous articles published on the subject.

WOUND TREATMENT

The treatment of the wound has varied for the individual case and has depended more on general surgical principles than on the teaching of a single school such as the Carrel-Dakin. We are definitely of the opinion that the majority of properly operated wounds progress more quickly and favorably if dry rather than wet dressings are used. For drainage purposes we prefer soft rubber tubing with an inside bore of about a quarter of an inch. The cases operated "up the line" and received by us shortly after operation showed when dressed in this manner far less gas gangrene and serious infection than did those cases packed with gauze, irrespective of whether the gauze was packed loosely or tightly or whether Carrel tubes were used or not. In practically every suppurating compound fracture of the femur, especially those above the lower third, it is well to provide posterior stab drainage just below the gluteal fold, infection frequently spreading toward and gravitation assisting in localization at this point.

LATE OPERATIVE TREATMENT

The late operative treatment resolves itself into the opening of abscesses, the removal of sequestræ, the occasional removal of retained foreign bodies giving symptoms, and most rarely the secondary closure of the wound of the soft parts. Abscesses should be opened as far as possible posteriorly. With preventive early stab wound drainage just distal to the gluteal fold, fewer operations for secondary abscesses will be found necessary.

Sequestræ should be removed when loose. The operation should be made a formal one, done with good exposure and under direct vision. It has

been our experience that even with the most careful X-ray work the pre-operative and operative findings do not always agree. Bone appearing most certainly dead and separated under the X-ray may be found at operation attached and viable, and loose ivory sequestræ found at operation may not have been seen in a good pair of stereoscopic plates. If possible, it is wise to perform the sequestrectomy with the splint still in place and with traction maintained. Refracture can thus be avoided. By careful clean operative technic under good exposure, *all* sequestræ can frequently be removed at one sitting, thus obviating the necessity of further operation at a later date. In the majority of instances it is the overlooking of already present sequestræ rather than the later death of bone which makes subsequent sequestrectomy necessary. Terminal sequestræ should be removed only when complete separation has taken place. They can often be knocked loose by the sharp blow of a blunt instrument. Too early removal simply insures the death of more bone.

Secondary suture of compound fracture wounds is a dangerous procedure and irrespective of bacteriological findings is rarely to be advised. It should never be done in the presence of a sinus, and if properly done with complete dissection of the scar tissue, a potential sinus is immediately established. It has not been allowed in any of the cases of this series, but we have seen disastrous results following such a procedure in other parts of the body.

Foreign bodies overlooked at the primary operation should be sought for and removed later only if giving rise to pain or if associated with abscesses or sinuses. In these latter cases it will often be found that it is a small bit of clothing rather than the metallic foreign body which is at fault. It has been our habit to personally fluoroscope these cases in two planes and to then depend on the electro-vibreux for localization in the open wound. Using this technic, very few magnetizable bodies have not been found. There is enough magnetizable metal in the casing of a German bullet to vibrate with this instrument. Bullet forceps we have discarded. In their place we prefer a finger and a dull Volkmann spoon.

MORTALITY

Of the 131 cases, 26 died, a mortality rate of 19.8 per cent. The causes of death in these cases were as follows:

Gas gangrene	7
Gas gangrene with secondary hemorrhage	2
Gas gangrene (late) after sequestrectomy	1
Streptococcus sepsis	13
Streptococcus sepsis with tetanus	1
Tetanus	1
Lobar pneumonia	1
	<hr/>
	26

FRACTURE OF THE FEMUR

Thus gas gangrene was responsible for 34.4 per cent., sepsis for 53.8 per cent., tetanus for 3.8 per cent., and lobar pneumonia for 3.8 per cent. of the total mortality.

The deaths occurred during the following periods after injury: First week, 3; second week, 3; third week, 8; sixth week, 2; seventh week, 1; eighth week, 2; ninth week, 1; tenth week, 1; eleventh week, 2; twelfth week, 1; fourteenth week, 1; sixteenth week, 1. It will be noted that the heaviest death rate occurred during the first three weeks, and that during the fourth and fifth weeks no deaths occurred. Of the early deaths, 7 were due to gas gangrene alone and 2 others to secondary hemorrhages in gas gangrene cases. There were three early deaths from streptococcaemia, and one each from tetanus and lobar pneumonia.

With the exception of one acute gas gangrene flaring up after a sequestrectomy and dying in the eighth week, all the late deaths were due to the streptococcus. There was one late death from tetanus, but this case also had a positive streptococcus blood culture and at autopsy showed multiple streptococcus foci.

This mortality rate is altogether too high. We have already (pages 478 and 480) itemized 19 deaths which we considered avoidable. Others were unquestionably unnecessary. Tetanus should never be allowed to play its part. With adequate hospitalization and transportation facilities, gas gangrene should be eliminated as a contributing factor. The streptococcus as a problem in wound and subsequent systemic infection can up to the present time only be combated by adequate and early operative procedure. Some of the later manifestations must be controlled by amputation, not too long deferred.

CONCLUSIONS

1. A compound fracture of the femur should be operated upon and held for a month, or immediately transported without operation to a hospital where definitive treatment can be carried out. It is an injury of war whose mortality rate is high and whose late results are often crippling. It is an injury to which a sufficient amount of attention is not paid, possibly because often associated at first with relatively small wounds which to the unpracticed eye do not forebode serious results. But it is from these wounds, no matter how small, that the danger arises. Closed fractures of the femur are not of particular danger. Given an associated local wound of the soft parts, and the prognosis becomes immediately worse. And given a combination of the two with an inexperienced surgeon doing inexperienced surgery and an inexperienced "triage" officer indiscriminately evacuating the cases, and the prognosis becomes distinctly bad. We are of the opinion that these cases should either be operated upon and held at an advance hospital for at least a month, or else given priority in transportation and immediately evacuated to a hospital in the rear which can be reached in less than twenty-four hours after injury and in which the patient can be held for at least four weeks.

2. The chief danger lies in infection, gas gangrene in the early weeks and streptococcus in the later weeks. Both can be best combated by early, adequate, and radical surgery.

3. Bullet fractures are practically as dangerous as are those by shell fragments. The occasional bullet wound may be observed without operation, the shell wound never.

4. Those fractures splitting into the hip- or knee-joints are infinitely more dangerous than those involving only the intermediate portions of the bone. Those involving the hip should probably always be amputated and then disarticulated. The majority of those involving the knee will need resection or amputation.

5. The primary operative procedure should be radical to the point of apparent brutality. We have never seen too large an incision. We have seen many pitifully inadequate ones.

6. Amputation should be done oftener and earlier. Too many attempts are made with results disastrous to life to save worthless limbs.

7. The ideal form of traction is skeletal, and this form of traction is practically without danger. Femoral traction is superior to tibial traction.

8. If more care were paid to operative treatment, less would be heard of the chemical treatment of wounds. Such treatment would be unnecessary. General Cuthbert Wallace¹ of the Royal Army Medical Corps, after tracing the rise and fall of the various antiseptics which have been advocated since 1915, deprecates their use, and speaking of the surgery of wounds of war, closes as follows: "I think now we have come to our senses. People talk about revolution in surgery. It is a return to sanity—to ordinary civil practice. You will find that the more war surgery approximates to civil surgery the better it will be. . . . The improvement that has taken place in the wounded is simply due to the fact that one now does what one was taught to do in the days of one's surgical infancy."

We feel that this paper could not be complete without a word of appreciation of the man under whose guidance the treatment of these cases has been. Without the constant support, professional wisdom, and personal stimulation of Colonel Joseph A. Blake, Commanding Officer of the hospital and later Surgical Consultant of the District of Paris, the work must inevitably have lagged and the mortality rate risen. To work under him was a pleasure, and to go to him for advice and assistance always resulted in valuable help and encouragement. The American people and especially the troops who, when wounded, had the good fortune to come under his command, owe to him a great debt of gratitude. As an executive officer he was always just, as one with a trained surgical mind and hand he was unsurpassed, and to his staff he was always a friend.

¹ *The Medical Bulletin*, Par. 1918, 1, 364.

THE DISINFECTION OF VITALIZED TISSUES AND THE HEALING OF WOUNDS WITH CHINOSOL AND SALT*

By WILLIAM C. LUSK, M.D.

OF NEW YORK

PROFESSOR OF CLINICAL SURGERY AT THE NEW YORK UNIVERSITY AND BELLEVUE HOSPITAL MEDICAL COLLEGE;
ASSISTANT VISITING SURGEON TO BELLEVUE HOSPITAL

THE objective is to bring positive and convincing proofs of the healing value of chinosol in combination with salt.

Chinosol is pure normal oxyquinoline sulphate. *In vitro*, though a powerful antiseptic, it is very little germicidal. A 2 per cent. solution did not kill staphylococcus aureus in twenty-four hours. Its disinfectant action on vitalized tissues is therefore probably due to the excitement by it of physiological stimuli to bring nature's forces of resistance to the fore.

Salt was combined with chinosol by the writer through the influence of the writings of Col. Sir Almroth E. Wright¹ relating to salt in the treatment of wounds.

Clinical Experience.—Examples of cases treated with chinosol and salt are as follows: Primary union in incised wounds, as, for instance, a case of cut tendons of the wrist; cases of acute suppuration, as one of cellulitis of the leg covering an area about the size of one's hand, due to colon bacillus, with sloughing interior, in which, with the use of a solution of 2 per cent. chinosol and 5 per cent. sodium chloride, the opposing surfaces of the abscess cavity were almost completely united on the ninth day; the healing of a whitlow with bone involvement without destruction of the tendons (function returning) and with union of the soft parts to the area of exposed bone, the latter having taken place by the tenth day, using a solution of 2 per cent. chinosol and 0.85 per cent. sodium chloride; the filling with granulations, in about five weeks' time, of a bone cavity about 7 inches in length in an expanded lower portion of the shaft of a tibia, resulting from an operation for osteomyelitis, the whole medullary portion of the bone having been removed, treatment having been by a daily application of gauze wet with a solution of 2 per cent. chinosol and 0.6 per cent. sodium chloride for two hours; the healing of a pelvic fistula 6 to 8 inches in length, by injections, at first daily for one month with a solution of 2 per cent. chinosol and 5 per cent. sodium chloride, with which treatment the fistula became reduced to $2\frac{3}{8}$ inches in length, later having been completely closed with the use of the tincture of chinosol; the cicatrization of a deep wound entirely encompassing the anus, the result of the separation of a slough, with high retraction of the anus above the skin surfaces of the buttocks, so that

* Foreword to an uncompleted paper read before the N. Y. Surg. Soc., Feb. 12, 1919.

¹ Wright, A. E.: *Lancet*, 1915, ii, p. 1009; 1916, i, p. 1203; 1918, i, 831.

in three and one-half weeks' time the anus was pulled down and united even with the surrounding skin, treatment having been by the daily application of gauze wet with a solution of 2 per cent. chinosol and 2 per cent. sodium chloride for about one-half hour; the complete removal of a deep slough filling the base of a large carbuncle of the neck, which had been incised, with the adhesion of the undermined skin edges almost everywhere to the surface of the ulcer underlying them, by the fourteenth day, using a solution of 2 per cent. chinosol and 0.85 per cent. sodium chloride.

A chinosol ointment and a tincture of chinosol have important uses. The ointment (℞ chinosol grains vi, sodium chloride grains ii, lanolin and vaseline āā ℥ss) rubbed in for four or five minutes once in two or three hours, has proved a pretty reliable agent with which to abort beginning hair-follicle infections. The tincture (℞ chinosol, 2 per cent., and sodium chloride grains iss to the ounce in 80 per cent. alcohol) applied once a day to the skin around a furuncle, after having removed the grease with a fat-solvent, will prevent infection of neighboring hair follicles.

The technic is simple, application of the chinosol-salt aqueous solution in suppurating and granulating wounds which are accessible being made by means of gauze which, when the wounds are discharging, is left in place between daily dressings, but when the wounds begin to granulate healthily with little discharge, should be removed in two or three hours following the dressing, to permit collapse of the wounds. The solutions used in this class of wounds contain 2 per cent. of chinosol with either 0.85 per cent. or 5 per cent. of sodium chloride. The combination of this strength of chinosol with the hypertonic salt probably promotes cicatrization to a greater degree than does that with the iso-tonic salt, while the latter combination probably promotes the growth of granulations more than does the former. These solutions on contact with the wound cause a burning sensation which quickly passes away.

The healing of blind tracks of soft parts may be facilitated by injecting the tracks once in six or eight hours through tubes having no punctures, introduced to their bottoms, for which purpose the 2 per cent. chinosol solution having the 5 per cent. salt content is probably the preferable solution of the two. The tincture of chinosol (℞ chinosol 2 per cent. and sodium chloride grains iss to the ounce in 80 per cent. alcohol) has seemed particularly advantageous for the healing of blind fistulæ *in ano*, though with a different technic, it being injected into the track two or three times at fifteen to thirty minute intervals each day.

For the control of sepsis in a draining empyema case, the solution of 2 per cent. chinosol with the 5 per cent. sodium chloride content is recommended, one ounce of which may be injected into the cavity daily, to be retained by posture, following preliminary washing with salt solution. In one case the use of a 5 per cent. salt solution for the preliminary washing seemed to avail more toward cicatrization and healing of the wound than had nor-

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mal saline. Wright has shown that a preliminary wash of a pus-secreting surface with physiological salt solution to remove the albuminous substances, gives an after-coming antiseptic an opportunity to reach the bacteria. Before dressing a wound, the surrounding skin is first wiped with McDonald's solution (alcohol 60 parts, acetone 40 parts, to which 2 per cent. of pyxol is added).

First-aid treatment is effected either by packing the wound with gauze saturated with a solution of chinisol iv grains to the ounce and 0.85 per cent. sodium chloride, which may be left in place for twenty-four hours before repairing or redressing the wound, when the same solution should be used again, or by simply sponging the wound freely with the solution during the operation for its immediate repair. The above gauze pack, after remaining in a fresh wound for twenty-four hours, often adheres to well-nourished tissues. Hypertonic salt should not be used in a fresh wound which is to be sutured.

In both old and fresh wounds which gape, it is advisable to interpose a piece of rubber tissue between the gauze which brings the chinisol salt solution into contact with the wound and the external dressings, in order to prevent abstraction of the solution into the latter.

Animal experimentation was done to prove the value of chinisol as a first-aid disinfectant. In the animal experiments the wounds were constructed as pockets between the superficial and deep layers of the superficial fascia in a dog's back. These pockets, when made blood-free, would absorb the solution very freely no matter what was the strength of the salt, but when the tissues were infiltrated with blood the absorption of the solution would be slower or sometimes there would be none at all.

The instances in which primary union followed the disinfection of a scientifically infected wound, where the infection preceded the disinfection, were not frequent. One case which gave encouragement to the work was that of a dog infected with staphylococcus aureus, having used as much of a twenty-four hour culture as could be taken up by a piece of gauze about 1 by 1¼ inches square, crumpled up, which was left in the wound for thirty minutes, the wound then being disinfected with a solution of chinisol grains vi to the ounce and 0.6 per cent. sodium chloride, in which primary union took place in the disinfected wound, while from the control wound on the opposite side an extensive cellulitis developed, which resulted in a large area of superficial necrosis with ulceration extending from near the backbone forward to the anterior median line.

In a recent series of experiments consisting of 12 dogs, in which the lymphatics leading from *wound pockets* between the layers of the superficial fascia, *uncontaminated with blood*, were first infiltrated with the disinfectant solution before infecting the wounds for thirty minutes with as much of a virulent twenty-four hour culture of staphylococcus aureus as could be absorbed on a piece of gauze about half an inch square, crumpled up, and the disinfectant solution was applied to the wounds again following the

infection, the wounds having been finally sutured primarily, these same wounds in seven of the animals united by primary union, while the controls all suppurated. The strengths of chinisol used in this series of animals were grains iv and vi to the ounce, and 2 per cent., and of sodium chloride, 0.85 and 0.6 per cent.

In two similar experiments with *blood-infiltrated wounds*, in which solutions of chinisol grs. vi to the ounce in combination with 0.6 per cent. and 0.85 per cent. sodium chloride respectively, were used, each of the wounds thus treated exhibited an area of dark gray staining of its fatty interior, due to a change produced in the infiltrated corpuscles in the course of from fifteen to thirty minutes by the action of the chinisol, and both of the wounds suppurated, pure staphylococcus aureus having been found in the pus from each, while the control wounds, also infiltrated with blood, both united by primary union. These results led to a study of the action *in vitro* of solutions of chinisol and salt, on washed blood corpuscles. In this connection, it is of interest that two *sterile* blood-infiltrated wound pockets in the subcutaneous tissue of a dog, treated with a solution of 2 per cent. chinisol in combination with salt, with resulting areas of dark gray and gray-black staining, following primary suture, united by primary union. With the use of the first-aid solution (chinisol grs. iv to the ounce and 0.85 per cent. sodium chloride) in experimental wounds into which blood had flowed, a smoky yellow color and occasionally a light grayish tinge have been noted, usually affecting the loose connective tissue joining together the superficial and deep layers of the superficial fascia, which at the same time has become the seat of an œdema resulting from an infiltration of it by the solution. In fresh traumatic wounds, staining of the tissues attendant upon the use of the first-aid solution has, in a limited experience, not been a feature.

These experiments have shown that the production in fresh wound pockets uncontaminated with blood, of immunity to scientific infection with a large number of virulent staphylococci aurei, by the use of chinisol with iso- and slightly hypo-tonic salt and once by the use of 2 per cent. chinisol alone, has been accomplished in a majority of the instances, which furnishes *proof* of the disinfectant action of chinisol on vitalized tissues. The practical application of this knowledge would be to the first-aid treatment of wounds. Thus it would seem that, if fresh traumatic wounds could, within the first few hours of their receipt, at a time when, as Carrel and Dehelly have shown, bacterial growth has hardly begun, have their open lymphatics blocked with a solution of chinisol and iso-tonic salt, comparable to the lymphatic block with the disinfectant solution preceding the scientific infection with a large number of virulent bacteria in the dog's wounds, that immunity of these wounds, at least to the ordinary pus germs, in the presence of a but comparatively trivial amount of in-

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fection at this early period, could similarly be expected. The lymphatic block of a fresh traumatic wound with chinosol and salt should be superficial, since in the animal experiments an extensive infiltration of the solution into the lymphatics opening into a wound, following scientific infection of the latter, seemed many times to have been the probable cause of extending the infection to a distance from the site of its implantation. Although blood infiltration associated with the use of the chinosol salt solution as described, might be incompatible with the production of immunity against a severe scientific infection in an experimental wound closed by primary suture, yet this same condition would not necessarily be incompatible with producing a lymphatic block against the invasion of the tissues by bacteria or with arresting bacterial growth, in a traumatic wound treated open by the introduction into it of gauze packing saturated with the disinfectant solution, especially when the latter is introduced early before the bacteria have begun to multiply greatly.

Twenty-four grains of chinosol in solution have been infiltrated into the lymphatics of a sterile, fresh wound in the back of a dog weighing 8 kilos, with primary union and without complication.

Miss W. Carey Noble, of the Research Laboratory of the New York Board of Health, has made very careful bacteriological tests with chinosol, which virtually confirm the tests of the Council on Pharmacy and Chemistry ² of the American Medical Association.

Dr. Alexander O. Gettler, pathological chemist to Bellevue Hospital and to the City of New York, has done important work on the chemistry of chinosol to incorporate in this report.

Mr. Pro. V. Prewitt, Instructor in Physiology at the New York University and Bellevue Hospital Medical College, has done a valuable piece of work on the action of chinosol alone, and in combination with salt, on blood corpuscles.

The merits of chinosol in combination with salt as a tissue disinfectant can be summarized as follows: Its stability, its ease of application, its applicability to first-aid treatment of wounds, its tendency to dry up pus, its non-irritability when applied in accordance with the technic here advocated, unless possibly after prolonged use; also the facts that it appears not to attack tendons and that it facilitates the separation of sloughs.

² Report on Chinosol of Council on Pharmacy and Chemistry, American Medical Association, Journ. A. M. A., 1910, liv, p. 1801; editorial, p. 1790.

A SERIES OF WAR WOUNDS TREATED WITH DICHLORAMINE-T *

BY PENN G. SKILLERN, JR., M.D.

OF PHILADELPHIA

ON the morning of August 17, 1918, at eleven o'clock, in latitude 42° 56' N., longitude 30° 08' W., a depth bomb exploded prematurely on board the U. S. S. ———, bursting into thousands of fragments, which peppered alike objects animate and inanimate, killing four men and injuring twenty-three others. Stretcher-bearers transported the injured to the sick bay, where they were undressed, turned into fresh, clean bunks and given restorative measures, including heat, opium, and fluids. First aid dressings were hastily applied, and when the patients were out of shock tetanus antitoxin was administered.

To cope with this situation there were on board three medical officers, of whom Lieutenant Commander C. K. Winn, U. S. N.—the Senior Medical Officer at that time—directed the author to take charge of the operating room, whilst he and Lieutenant R. M. Krepps, U. S. N., supervised the work in the sick bay. In order to determine the location, nature and extent of the injuries the author had each man in turn placed on the operating table, stripped. He then examined minutely each man from head to foot, dictating to a hospital corpsman standing by the location, nature and extent of every injury as soon as it was encountered. This search revealed injuries, of which those included in the following list were the most important:

List of the More Important Injuries.—Perforation of bowel, 4; penetration of lung, 7; laceration of femoral vessels, 2; laceration of penis and scrotum, 2; laceration of eyeball (extensive), 1; rupture of ear drum, 8; fracture of skull (occipital), 2; fracture of mandible, 1; fracture of humerus, 2; fracture of radius and ulna, 1; fracture of femur, 1; fracture of femur (incomplete), 1; fracture of patella, 1; fracture of tibia and fibula, 2; fracture of tibia, 1; fracture of tibia (incomplete), 2.

This list by no means represents all the injuries, for there were numerous punctured and lacerated wounds of various soft parts. The fractures were for the most part compound and many were comminuted. It is now evident that in the entire group of patients several hundred injuries had to be discovered and dealt with. This search consumed twelve hours from the time of the accident—from 11 A.M. to 11 P.M. After the last man had been examined those who had been set aside for operation were taken up, and the operations were finished by two o'clock the following morning.

* Presented before the Philadelphia Academy of Surgery, April 7, 1919.

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The importance of such a minute, painstaking examination from head to foot in this series of injuries is shown by the following case:

P. A. S., seaman, was carefully and minutely examined from head to foot, but the only injury found was a small punctured wound just below the navel—a puncture whose diameter was no greater than the cross section of a matchstick. The patient complained of no symptoms, yet the probe when introduced reached a depth that corresponded to the whole thickness of the abdominal wall. Exploratory celiotomy revealed in the small bowel two perforations of matchstick diameter, while in the mesentery near by there was found a small scale of metal no larger than a grape seed.

In the second case of bowel perforation the two apertures were larger, being jagged holes with at least the diameter of a lead pencil. In this case the jagged edges were inverted, and the two sutured sites were reinforced by free grafts of omentum. The portion of bowel involved was jejunum, and for a few days after operation the patient presented signs of dynamic ileus. This was attributed, however, to reaction œdema of the inverted bowel edges: after several stomach washings the lumen of the bowel restored itself and the ileus disappeared.

In the third case of bowel perforation it was the cæcum that was involved. No operation was attempted because the missile had entered well laterally in the right lumbar region and on its way to the right iliac fossa injured the outer portion of the cæcum, whose contents could freely reach the surface through the large hole made by the missile: a cecal fistula in this situation does not imperil the patient's life. This patient had, in addition, a penetrating wound of the right lung and extensive lacerated wounds of the left thigh and right axilla. He eventually made a complete recovery.

The only fatal case of bowel perforation did not come to operation because the patient was instantly killed, the result of multiple extreme injuries.

Of the seven patients with penetrating wound of the lung six recovered, aspiration of hæmothorax being required in several cases. The fatal case never reacted from the shock of the accident, two hours after which he died, the result of multiple extreme injuries. There was a hole in the left side of his chest through which a fist could be introduced, and it was impossible to seal this hole owing to the patient's precarious state.

One patient had a deep laceration of the dorsum of the penis, just behind the corona glandis. The wound itself was packed to check brisk bleeding from the corpora cavernosa. To prevent subsequent phimosis from reaction œdema of the foreskin, the prepuce was slit transversely just distal to the corona glandis, and the head of the penis was drawn through this slit like a button through a buttonhole, the foreskin dropping posteriorly. A gum catheter was passed into the bladder and retained. The

foreskin proved useful later, when it came to plastic repair of the penis. The wound healed without producing angulation.

The patient with extensive laceration of the eyeball came eventually to enucleation. He was the nephew of a prominent Philadelphia oculist.

There was no operative mortality in this series. The four men who died either were killed outright or succumbed to shock, the result of multiple extreme injuries, within a few hours of the accident. The twenty-three survivors ultimately were either sent to duty or honorably discharged from the service.

The chief purpose in reporting this series, however, is to attest the value of dichloramine-T. Stimulated by the paper on the use of dichloramine-T read before this academy by Lee and Furness on October 1, 1917, the author used this preparation and became a stanch advocate of it and carried with him a quantity to sea. The primary dressing of each wound after the accident consisted solely in filling the wound with dichloramine-T and inserting a short length of rubber dam to maintain the patency of the drainage orifice of the wound. Then over all there was applied and secured a dry, sterile gauze pad. The ship reached port on the twenty-second of August—five days after the accident. The patients were then transferred to a hospital. At the time of transfer *not a single one of the numerous wounds had become infected*—no patient's chart showed elevation of temperature. And several months after the accident the author was told by the surgeons who attended these patients at the hospital that *not a single wound developed the slightest evidence of infection*: what cultures were made from wound discharge invariably proved sterile.

The author wishes to express his appreciation of the action of the surgeons of the U. S. Naval Hospital, Brooklyn, in reserving for him the privilege of reporting this interesting and in many ways unique series of cases.

REMARKS ON THE ETIOLOGY, INDICATIONS FOR TREATMENT, BEHAVIOR, AND POST-OPERATIVE COURSE OF EMPYEMA THORACIS*

By A. BELCHAM KEYES, M.D.

OF CHICAGO

MAJOR, OFFICERS' RESERVE CORPS, U. S. A.; SURGEON TO COOK COUNTY HOSPITAL

ALTHOUGH the overwhelming variety of valuable statistics recently published have added very much to our knowledge of the etiology of empyema; the writer feels that consideration of the indications, behavior and operations from another angle may be of much use to consider.

The Indications in and for the Operation Are.—1. Pressure dyspnoea. Sudden deaths have been attributed by Trousseau, in rapidly occurring copious pleuritic exudates (especially when left-sided), to quick movement or cough, causing torsion of the aorta due to the displacement of the heart, resulting in loss of consciousness and sometimes death from interruption of the cerebral circulation or quick thrombus formation.

Bartels considers that the death in these cases is due to a kinking of the vena cava at its point of passage through the diaphragm, the latter often being spasmodically contracted during violent cough. (No such case has been observed by the writer.)

2. (a) To avoid allowing fluid compression to remain so long as to cause "*permanent changes in and deposit on the pleural surfaces,*" resulting in thickening, contractions or adhesions, also changes in the lung itself consequent on long continued hindrance to expansion; resulting in various degrees of permanent acquired atelectasis.

(b) The early removal of a part of the fluid by aspiration, by relieving pressure on the pleural lymphatics, together with the increased pump-like action of respiration on these vessels, frequently results in complete resorption of the exudate in cases not positively purulent.

3. To remove pus as early as possible after the diagnosis of "true empyema" is made, by thorough "dependent permanent" drainage, saving, if possible, the infection of the neighboring organs in the more acute cases, the breaking through the diaphragm into neighboring cavities, or through the chest wall (*necessitatis*), the hectic fever and possible nephritis or death.

4. A "premature" open operation in pleuritic effusion should be also studiously avoided. (Active acute or subacute lung processes (a) if "*on the same side as the exudate*" are, as a rule (except, perhaps, in certain very rare cases, *e.g.*, a pleuropulmonary abscess), a contra-indication to an early "open" thorax operation (thoracostomy), usually at most only aspiration by a syringe should be done. Active acute or subacute processes (b) "*in*

* Approved for publication by the Surgeon General, U. S. Army.

the other lung and pleura" should also be absent, for an open operation causing a pneumothorax on one side requires that the other lung must be sufficiently normal to do double work.)

5. To avoid very sudden removal of large amounts of fluid in much distended pleural cavities, thereby giving rise to shock, hemorrhage into the bronchi, lung substance, and pleural cavity and perhaps death.

6. To avoid the unnecessary entrance of infection or foreign bodies into the pleural cavity during or after operation.

7. To observe "the strictest possible" measures of surgical cleanliness in even the smallest operations on the thorax.

8. To aid in the return of functional lung activity at and after operations.

(The tension of the exudate, according to Leyden, is exceptionally -2 or 0-, ordinarily it attains 20+ and 28+. This pressure is not alone dependent on the quantity, but is usually less in the debilitated and aged; with rigid thorax and usually greater in young people with more acute infection and elastic thorax. Lemoine remarked that serofibrinous effusions with specific gravity above 1019 are favorable cases; those below 1015 unfavorable, but to-day we resort to the microscopic examination, the culture tube, and inoculation for information as to the etiologic factors.)

9. Inflammatory exudates and empyema may be: (a) primarily pleuritic (hæmatogenous, rare), or (b) secondary to lung infection (usual), or (c) secondary to pericardial or subphrenic abscess, or (d) via penetrating wound of thorax. (Transudates of cardiac, renal or hemic origin are not the subject of this paper.)

10. While microscopic examination of smears and cultures must always be made, it is also very necessary to be conversant with the clinical relation of etiologic factor to *macroscopic* appearance.

(a) *Tubercular Pleuritis*.—The statement that all "exudate" cases are tubercular in which we find no microorganisms at all, as well as those few in which tubercle bacilli are proven present, we know to-day is only relatively correct; *e.g.*, pneumococci, which may be the cause of the exudate, die in the presence of tubercle bacilli quite frequently.

Tubercular pleuritic exudates are often clear, may be cloudy, purulent, or even hemorrhagic. Tuberculosis mixed with pus (streptococcus or staphylococcus) while more rare in "recent" is more liable in advanced pulmonary tuberculosis with cavities or pyopneumothorax, in which latter as well as in some lung abscesses saprophytic infection may also occur. In purely tubercular cases the leucocytosis is low. In simple cases only 9 or 10 per cent. have over 12,000.

(b) *In acute lobar pneumonia* from the pneumococcus alone pleuritic exudates may occur during or after the attack, may be clear but are more often somewhat cloudy, and often slow of absorption; but "true empyema" is comparatively rare, unless "mixed" pneumococcus with streptococcus or staphylococcus be present. According to "Lord," pneumococci are difficult to cultivate from pleural exudate in which they were a

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coexisting factor; they were cloudy, 53 per cent.; purulent, 16 per cent.; hemorrhagic, 10 per cent.; the rest were clear.

In a cloudy pneumonic exudate one should never be precipitated into "operating" too early; also a few staphylococci in the culture from the aspirated fluid of these may be from the skin during aspiration.

(c) *In bronchopneumonia* the above observations, generally speaking, hold good: (1) In bronchopneumonia the exudate may be tubercular or tubercular mixed infection, or (2) it may be frank localized pneumococcus pneumonia or pneumococcus mixed, or (3) a purely local extension of a purulent bronchitis and bronchiolitis, general or local, to a pulmonary lobule and thence to the pleura with pleuritic exudate often streptococcic, less often staphylococcic; here also is great need for very mature consideration before "open" operating, (4) as to the nature of the exudate, the activity of the process in the same, and also in the other lung, and pleura; when and where to operate.

(d) *In embolic pneumonia* and pleuritis, a pulmonary embolism from a remote area of traumatic non-infectious or infectious thrombophlebitis may be (1) big enough to kill suddenly, or (2) if small and non-infectious absorption with subsidence of all symptoms and healing by a wedge-shaped lung "infarct" without or with resorbable pleuritic exudate or adhesions, or (3) if infectious, one or more abscesses of the lung may occur and either localized single or localized multiple foci of, or a general empyema, demanding one or more operations. (4) Great care is necessary in these operations to avoid coughing, sneezing or vomiting, which might result in the detachment of another embolus.

(e) *Empyema from infection from without (penetrating pleura wound)* e.g., stab, bullet, or, indeed, following paracentesis or premature open operation.

(f) *Empyema may be secondary by contiguity* (1) to a primary pericarditis; or (2) secondary to subdiaphragmatic lesions or subphrenic abscesses breaking upward infecting the pleural cavity, from the liver, kidney, spleen, perforating stomach or duodenal ulcer. One case by Novack was from a suppurating vermiform appendix; and Kelach reported finding Eberth's bacilli in hemorrhagic, and Fernet in serofibrinous pleuritic effusions (Société Médicale des hôpitaux, 1891); (3) lastly, chylous from intrapleural rupture of a lymph-vessel.

While Netter's 109 cases, reported twenty-five years ago, of streptococcus, 44; streptococcus and pneumococcus, 2.8; pneumococcus only 26.7; staphylococcus, 1.8; tubercular and putrid, 24.7; are practically the same as the findings of the present day, yet the vast number of recent cases studied and the much wider bacteriologic and clinical experience has so dwarfed our past knowledge as to make it idle to repeat, it yet prompts us to suggest that, though (a) most of the cases studied were undoubtedly empyema, (b) some are probably a general septicaemia with pleural implication.

Behavior of Pleuritis and Empyema.—(1) The opinion of years ago that

streptococci usually only infect the pleura if gaining access to the pleural cavity in sufficient number, and often only then if there is pathological change at some point on the pleural surface (this focus often being too small to detect), and that injections of feeble cultures into the pleural cavity often do not infect the pleura if perfectly healthy, is in a measure true; but (2) that a pleura, though showing no marked change "macroscopically" post-mortem, while large quantities of virulent microorganisms are found on its surface was not in a condition of early inflammation, may be very wrong. (3) Physiologically, the pleural cavity surfaces resorb so very much more quickly the moistening serous fluid that is always passing into it in large quantities, that in health no free fluid remains. (4) In the very early stages of an acute pleuritis secondary to pneumonia the stomata and stigmata of the lymphatics may often be still wide open, and the serum, though passing into the infected pleural cavity in larger quantity than usual, is still *resorbed again so rapidly that no free fluid remains, but is converted in transit into toxins* of much virulence. If early death occur (not necessarily from the pleuritis) no free fluid may be found in the pleural cavity postmortem; indeed, in some cases of very virulent infection death may occur too quickly even for any macroscopic changes to have occurred upon the pleural surface, though very virulent microorganisms may be found in smears and cultures from it.

Prophylaxis.—Prophylaxis against pneumonia and empyema deserves the most careful consideration as to (a) contact infection; in food, clothing, bedding, barracks, or personnel; (b) the dusty air breathed in barracks or houses, on the drill field or in town streets; (c) the care of the respiratory tract mucosa both in health and disease, rhinitis, tonsillitis, bronchitis; (d) the use of antitoxins does not belong to this part of the subject.

Operations.—Where unresorbable or true purulent effusions are present we have the choice of several operations, all of which demand the most thorough surgical preparation, and performance by the surgical staff. Bed-paracentesis is too liable to convert a resorbable into an unresorbable exudate or true empyema.

(1) *Aspiration (paracentesis) with the hollow needle* and Dieulafoy's or Potain's vacuum apparatus is the only operation permissible for diagnostic purposes, and where true pus is absent often the only one necessary.

Trocar puncture does not sufficiently fulfil the indications, it being almost impossible to prevent the entrance of air with this instrument. Lefort, Manuel de Médecine Opératoire, many years ago remarked that empyema multiplied under its use. Pus was frequently present at the second, and very generally at the third trocar puncture. I need not to-day mention the great probability of an unclean field and trocar being the cause of the suppuration.

Simple thoracotomy performed early in pleuritic exudate without or with washing out the pleural cavity and reclosure, may allow the entrance of

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air into the pleural cavity and is of very questionable advisability. The cases of this kind would in all probability often have recovered without any operation, or, at most, aspiration of a part of the fluid.

The method of using the aspirating syringe as published by the writer in 1894 deserves special reiteration. The aseptic syringe needle should after careful surgical preparation be well buried in the soft parietal tissues (at a point indicated by the physical signs of pleuritic exudate) till the distal opening is entirely covered by the soft parts; "now produce a vacuum" in the receiver, after which the needle can be pushed slowly and carefully onward. Its entrance into the pus cavity is marked by the sudden filling of the syringe. This precaution makes us aware of the exact distance necessary to insert the needle and avoid wounding the lung. The needle should be provided with a "guard" so that its accidental insertion too far is impossible. The aspirating syringe does not permit the entrance of air and makes us independent of the degree of positive pressure. Only sufficient of a vacuum should be maintained to evacuate the fluid slowly through the needle.

(Raising the arm above the head will suffice to keep the skin wound from being in line with the pleural wound.)

Before saying what operation we should do we must also further consider what occurs in pleuritic inflammatory exudates.

1. In very low-grade inflammatory conditions with (1) the resorptive power still unimpaired with (2) the regenerative power only stimulated, (3) interlobar or pulmo-parietal adhesions occur, usually circumscribed over or around the area of primary lung involvement. In the latter case the exudate, if any, may later be resorbed, and perhaps entirely replaced by adhesions.

2. In virulent "local" pulmonary pleuritis the affected area is comprised of three zones: (1) the zone of inhibition (non-adhesions), lying immediately over the pulmonary focus; surrounding this we have (2) the zone of plastic adhesions; and still more peripherally, (3) the zone of regeneration and true circumscribing fibrous adhesions. This third zone (a) becoming strongly adherent, a purulent exudate becomes circumscribed permanently, or (b) if the circumscription is weak it may rupture and a secondary diffuse empyema may result.

3. In very acute cases the infection on the pleura may spread by continuity over the weak plastic and regenerative zones too rapidly for any true circumscribing adhesions to form, so that an unresorbable exudate or true empyema becomes diffuse or general from the beginning.

4. The inflammatory exudate may also, because of the early fibrinous or small cell infiltration, plugging of the stomata and stigmata, be so rapid that the pulmo-parietal pleural surfaces are too rapidly separated, so that adhesions are impossible and the exudate from the first is general or diffuse. (Transudates, being non-inflammatory, are always general.)

5. A virulent diffuse empyema pressing the lung into the vertebral gutter may cause so much infiltration or necrosis of the pleura that after drainage

the infiltration at first, later induration and adhesions, may act as a permanent hindrance to expansion even though the lung be comparatively healthy, or the lung itself may be also involved.

6. *Thoracostomy (vacuum) siphonage* (in which the intrapleural vacuum is still maintained). A "collapsed" rubber drainage tube is inserted between the ribs and sutured in place, the distal end being kept under water in a bottle. This is theoretically perfect, but difficult to carry out successfully always at the best site for dependent drainage. The vacuum favors lung expansion and favors drainage but may affect the inflammatory condition adversely by perpetuating congestion and the lack of rest. Whittemore's work in this connection certainly deserves attention and study. If the lung be already bound by adhesions firmly in the vertebral gutter it will not succeed in a cure.

7. *Simple (open) thoracostomy* (making a permanent fistula between the ribs).

(a) In children with less liability of previous pathologic changes in, and more expansive lung, with greater power of pleural regeneration, and greater flexibility of chest wall, placing a tube between the ribs in the thinner anterior axillary line is often sufficient, but in these, healing is often tardy and only with great deformity. The insufficient dependence of the drainage demands that the pulmonary and parietal pleural surfaces granulate together and literally gradually push the pus out. Pus if at high tension should be evacuated over a period of about two days, the opening being kept elevated and as securely closed as possible by copious wet dressings. After the second day the opening should be kept in the most dependent possible position. Much less shock may be experienced if a portion of the high tension pus is aspirated the day before the operation. The successful needle aspiration site is always a good guide for the open operation site. (b) In adults "selective" rib resection should, with rare exceptions, be the rule (see operation).

8. *Costatectostomy*.—Making a permanent "selective" fistula with resection of one or more ribs.

Just where shall we operate? (a) *In circumscribed empyema* we have no choice, the place of election being immediately over the site of the successful diagnostic needle puncture.

(b) *In empyema secondary to subphrenic abscesses* "breaking upward" we must choose the point that will give us the greatest advantage over both cavities, making counter openings, if necessary, to drain the pleural cavity.

(c) *Primary "multiple" resection of ribs* may be necessary, e.g., Case 2196, Keyes Records, Cook County Hospital, C. S., aged thirty-six, male. "Finding no pus on resection of the seventh rib immediately under the needle puncture site, the next rib below was also resected widely, the hand inserted, adhesions below broken up, and evacuation of a large quantity of yellow, creamy pus, followed by rapid recovery." No. 2287,

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J. C., aged forty, simple atelectatic low-pressure case, no pus flowed out, though it could be clearly seen and discharged itself immediately the patient was turned on his back, with rapid recovery.

(d) *In a diffuse general unilateral purulent exudate*, according to Lefort, we should operate: In a position (1) sufficiently dependent; (2) to avoid the diaphragm. In France the old rule was to choose a point between the ninth and tenth ribs on the left, and eighth and ninth on the right side; but as the diaphragmatic attachments are the same on both sides the rule is not sound. We can readily understand how by following this rule in *paracentesis* the aspiration of an empyema in the narrow complementary pleural space would be difficult, especially on the right side with the liability of piercing and infecting the diaphragm and liver. Certainly to do costatectomy so low is not devoid of risk. I have seen the peritoneal cavity opened by mistake on one occasion in Cook County Hospital by one of the most experienced operators. (3) *In thoracostomy* the two conditions are best fulfilled in general empyema, near the middle of the thorax, fourth to sixth rib. Here the incurvature is greatest posteriorly at a point between the inferior angle of the scapula and the posterior axillary line; here, with the patient in the dorsal position, we have the common junction and lowest point of three inclined planes extending from lung apex, from diaphragm and from vertebræ. (Besides the better drainage afforded (a) in general unilateral empyema, (b) most circumscribed exudates also occur posteriorly, due to the habit of patients lying on the back.)

The resection of a rib is to be preferred in adults, especially in those with more or less rigidity of the chest wall. The unfavorable conditions for expansion already present or which we are about to institute, *viz.*, a collapsed lung, a permanent pneumothorax with atmospheric pressure equal both within and without (instead of the negative within, causing increased lung expansion, and the heavier atmospheric without, causing increased chest wall depression), demands early operation and early total evacuation of pus; for in both *the tube between the ribs (thoracostomy)* and *the rib resection (costatectomy)*, we have a very much larger space between the "collapsed" lung and the undepressed chest wall to granulate up, and later on contraction must literally pull in the chest wall to the surface of the lung, or the lung out to the chest wall, usually some of both.

In considering the foregoing facts we cannot but recognize the deficiencies of all operative methods. Cases are on record where recovery has occurred by expectoration through a bronchus opening into the pleural cavity, but this bare possibility has no more to recommend it than the spontaneous evacuation by an insufficiently large spontaneous sinus (*necessitatis*) of the chest wall, which in nearly every case has a very tortuous course and is usually in a situation (anterior axilla) in which total evacuation of pus is impossible.

Operation for "general" unilateral empyema as advised in 1892 by the writer of this paper. With all due surgical precautions, the patient is placed in Sims's or a modification of Sims's position, according to the side to be operated upon, diseased side uppermost.

An incision 7 to 8 cm. long, immediately under the inferior angle of the scapula, directly over and along the middle of the rib to resect, extending through the periosteum to the bone. This latter is now carefully pushed off the rib anteriorly and also separated from it posteriorly, the bone (1½ inches) resected; the edges of skin are now sewn down near to the pleura, to cover the raw surface, and also to maintain the patency of the opening.

The anæsthetic is of importance to consider—a hypodermic of morphine sulphate (quarter of a grain) three-quarters of an hour before the operation may admit of its being performed "under local," or warmed ether may be employed according to "the Rovsing bag" method.

A small incision is now made in the pleura to allow the slow escape of pus. Should the pressure be very great within the cavity, the tearing open of the incision wider, with dressing forceps, can be deferred until the second or third dressing. The insertion of a tube in this operation is not absolutely necessary. *The patient should lie with the wound dependent always; to sit up is dangerous.* (Keyes records, 2618, Cook County Hospital: "Patient was doing so well that on request 'premature' permission to sit up was allowed, and drainage ceased. Autopsy revealed circumscription above the diaphragm.")

The less virulent case is often the most dangerous—the recovery is so rapid that the patient is often allowed to sit up or get up too early. The pus collects in the dependent part of the thorax, regenerative activity occurs above the level of the pus with pulmo-diaphragmatic pleural circumscribing adhesions and entire cessation of drainage, requiring a very bold secondary operation on a patient often in too poor condition to re-operate. The dressing of empyema cases after operation is a matter of the greatest importance. Antiseptic irrigation has its dangers; by it we may unintentionally convert a circumscribed into a general pleurisy or rupture weakened walls, and infect neighboring cavities, even with lethal issue. Solutions strong enough to have antiseptic effects are liable to be toxic, unless the drainage is perfect. We are dealing in most acute cases with a granular surface, that requires only to be early and thoroughly drained to heal; while washing is as little in keeping with these cases as it would be in peritonitis, and though irrigation is favored by some writers so long as the cavity contains putrid material, it is usually an excuse for imperfect drainage. The above references to antiseptic solutions and irrigating are not to be interpreted to include the Carrel-Dakin treatment, of which the author reads excellent reports but as yet has had no experience with.

The principal causes of "perpetual" pleural sinus after operation are:

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Non-expansion of the adherent pleura and lung, defective drainage, chronic tubercular pulmonary foci, foreign body, necrosis of rib.

(A lung and pleura, especially if the latter is not too much involved, may often still undergo some respiratory excursion immediately after operative pneumothorax is instituted. The spouting of pus at the primary operation is a good sign.)

The possibility of non-expansion of the lung appeals forcibly not only for early evacuation of "true" pus, but an attempt at a careful study of the condition of the lung as to its expansion at the primary operation, which can often be successfully made by inspection through the opening.

(a) The various secondary operations of multiple rib-resection devised by Estlander, Schede and others leave much to be desired. Of Berger's twenty-six thoracoplastic operations ten healed and five were improved. The lung is often so shrunken and adherent against the spine that the secondary extensive "multiple costatectomy" operation only is useless.

(b) Delorme, *La Semaine Médicale*, January, 1894, freely opened the chest wall widely, freed the lung from the false membranes that bound it in the vertebral gutter; when functional activity was restored at once, the "pleurotomy" opening being again sutured.

It certainly appears much more rational to aim at restoration of lung function than by the simple resection methods that as often fail as succeed; often only increasing the size of the outer opening, always *increasing the deformity and perpetuating the incapacitation of the lung*.

The early use of Beck's paste in the general pleural cavity in these cases is absolutely wrong.

One case entering my service at Cook County Hospital (after operation and Beck's bismuth paste injection) died an awful death by bismuth poisoning and was reported at length by my senior interne, now Captain Vernon, U. S. Army (*Journal A. M. A.*). Since then like unhappy results have also come under my observation.

The most careful re-consideration of the size and resorbability of the cavity is very necessary before making any rule.

ACUTE DILATATION OF THE STOMACH

By ANTHONY H. HARRIGAN, M.D.

OF NEW YORK

ASSOCIATE VISITING SURGEON, FORDHAM HOSPITAL

ACUTE dilatation is a somewhat unusual condition, the vagueness of the underlying mechanism and causation of which has stimulated the interest of the surgeon and the experimental physiologist. Indeed, its occurrence following abdominal operation is of startling and serious concern to the surgeon. It is impossible to detail, in a complete and critical analysis, the increasing and voluminous literature of the subject. As it would be futile to repeat and discuss all the factors, I shall, therefore, mention the salient points only, and review several leading articles, in order to orient the reader and to focus the attention on the dominant theories that have been advanced.

The literature of dilatation of the stomach is mainly expository from the clinical viewpoint. There are numerous articles, analytical in scope, and a few experimental and therapeutic. The authors, and they represent the general trend of all who have written on the subject, describe in detail the conditions with which dilatation of the stomach is associated, aptly illustrating a fact common in medicine, that if the mechanism or causation of a lesion is not clearly understood, a multiplicity of theories rapidly arises. The synonyms, "acute gastro-duodenal dilatation," "gastro-mesenteric ileus," "arterio-mesenteric obstruction of the duodenum," "acute gastric paresis," indicate and confirm this confusion. In the discussion of the etiology of dilatation, therefore, the various conditions with which it is associated must be mentioned. Of course, it is by no means proved that these are the exciting causes; indeed, it is possible that in the enumeration of these topics one is merely describing, as it were, the predisposing factors.

It is necessary, in order to obtain a clear grasp of the subject, to mention these factors in more or less detail. It is assumed that the occurrence of acute dilatation of the stomach is favored by prolonged dorsal decubitus. Certain clinical impressions exist which tend to strengthen this view. Excessive post-operative fasting and purgation have been considered auxiliary factors. A relaxed abdominal wall has been mentioned as a predisposing factor. It is believed that by a diminution of the intra-abdominal pressure, the intestines fail to maintain their normal level, assuming, consequently, a pelvic position. The cases occurring during the course of pneumonia have been explained by the propulsive action of the lung; this, aided by the paroxysmal coughing, forces the intestine down into the pelvis. The relation of the duodenum to the

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lumbar vertebræ is advanced by advocates of the arterio-mesenteric theory as a most important factor. The frequency of the association of dilatation with lordosis, scoliosis and kyphosis, makes it seem unlikely that these spinal deformities are mere coincidences. Indeed, the etiologic relation seems quite direct, so far as clinical reasoning can proceed. According to Piersol, the duodenum reaches its lowest point at a site opposite the fourth lumbar vertebra, over the disc, above or below it. In one-fourth of the cases it is opposite the third. It is rarely opposite the fifth vertebra and, if it is, it is probably pathological.

Since the time of Britton, the subject has received a great deal of attention from English and continental authors. The outstanding feature of the earlier literature is the clear and critical exposition of Fagge. The symptoms are detailed with a mastery characteristic of the English clinicians, the article emphasizing the degree of accuracy of observation in the writings of these older physicians. The etiology is not mentioned, the paper dealing, solely, with the symptoms and pathology. He gathered the few individual case records and notes then existing in text-books and transactions of medical and pathological societies. As some of these are based on doubtful analysis, they have not been included in statistical analyses. He brought out the important point that acute dilatation of the stomach may arise during various diseases. In describing several cases which came under his observation, he identified the condition as a clinical entity, wholly distinct from chronic dilatation consequent to stenosis of the pylorus. He states that visible peristalsis, so common in chronic dilatation, has never been seen in acute dilatation and that, even if it occurs, it would be almost invisible, for the contractions of the attenuated wall of the stomach would, necessarily, be extremely feeble.

An article by Smith contains illuminating comments and statements, and an analysis regarding the importance of the arterio-mesenteric obstruction. Though this may occur, he believes it is secondary to the primary distention of the stomach and the duodenal grooving is purely an accentuation of the normal anatomic crease. He stresses the fact that no case occurs save but following general narcosis, a point of doubtful value, for there may be a long lapse of time between the administration of the anæsthetic and the actual development of the dilatation. He also maintains that general intestinal paralysis exists, of which the stomach presents a special manifestation. He conducted several animal experiments, which, apparently, were not productive of definite results. He brings out the importance of the vagi in the artificial production of dilatation of the stomach. His animal experiments prove nothing save that division of each vagus nerve, beneath the diaphragm, close to the œsophagus, produced dilatation of the stomach.

The paper of Conner, an authoritative study and analysis of the subject, is a creditable contribution to American medicine. Not only is the general literature surveyed clearly, but each dominant clinical point

is emphasized and evaluated. Moreover, he does not accept the conclusions of previous investigators, but repeats in detail their experiments, amplifying them from the standpoint of technic. Conner's article is an exhaustive and comprehensive study of the then existing literature. Conner has leaned toward the arterio-mesenteric theory. (No doubt, he has been influenced towards the acceptance of this view by the findings in his own personal case.) Moreover, it is evident, from a reading of his article, that he has been greatly impressed by the work of Kelling. Conner, repeating and elaborating Kelling's experimental work, altered the technic somewhat by the introduction of a water pressure apparatus, to determine the degree of pressure necessary to overcome the obstruction in the duodenum. The paper, which is exceedingly stimulating, is sound in criticism and judgment.

It is manifest from a careful consideration of the symptoms detailed by many authors, that a more or less uniform entity exists under the heading of acute dilatation of the stomach. The striking unanimity of the symptoms is characteristic. Nevertheless, from a clinical viewpoint, it is evident that the symptomology of this disease differs from acute mechanical obstruction of the upper intestine. This point was forcibly brought to the writer's attention by a case which he had the pleasure to examine with Dr. Alfred Forman. The patient, a woman, suffered from a volvulus of the stomach. At operation, we found that the upper jejunum was incarcerated in the fossa of Treitz. The stomach, having rapidly dilated from the obstruction and strangulation, turned in its long axis, so that a distinct volvulus took place. The point that I wish to stress is, that though this particular case forms a striking example of acute obstruction of the upper jejunum, the analysis of the symptoms proves that there is a distinct difference between high intestinal obstruction from incarceration or strangulation and acute dilatation of the stomach. The symptoms appeared with extreme suddenness; profound shock, terrific abdominal pain, profuse vomiting, the crisis being reached in a few hours. On the contrary, acute dilatation of the stomach is often of slow development and progress. The onset is insidious, without severe or sudden abdominal pain. The signs of profound toxæmia rapidly supervene. Vomiting is often a negligible factor. Indeed, the condition may persist for days, or even weeks. Moreover, the macroscopic pathology differs markedly. In actual obstruction, the stomach is extremely swollen, red, congested, as in the case of a loop of obstructed intestine in a strangulated hernia, while the stomach, in acute dilatation of the stomach, is toneless, white or gray in color and presents absolutely no evidence of strangulation or incarceration. These two facts, the wide difference in the symptomatology and the distinct variation of the stomach and duodenum, as ordinarily understood, are in no way comparable to acute intestinal obstruction, as illustrated by a hernia of the upper jejunum in the fossa of Treitz. Reflection upon these points tends to convince the

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writer that the cause must be sought in a deeper study of disturbed physiology and not in the older conceptions of mechanical blocking, constriction, or obstruction.

One gains the impression from a perusal of the literature, that the numerous associated pathologic conditions, which have been so minutely recorded, have served merely as predisposing and favoring factors. In general, infection, anæsthesia and trauma form the ultimate analysis. The inference is irresistible that the discussion in the past has mainly concerned the general conditions favorable to the mechanism of production, and avoided all reference to the specific cause. Moreover a large amount of the experimental studies, so meticulously described, consists essentially in post-mortem examination of the stomach and duodenum. A fallacy is evident here, for the dead stomach is not, in any manner, comparable in its mechanism to the living. A striking feature of the recorded post-mortem examinations is the persistent emphasis placed on the toneless state of the stomach. It would seem from a superficial examination that the entire musculature is relaxed or paralyzed. An attempt to analyze this loss of tonus in the stomach and duodenum would involve, necessarily, a discussion of the physiology of tonus in general, a subject extremely comprehensive and one which, as yet, has not been sufficiently elucidated or developed in detail.

It has been maintained that duodenal dilatation does not always take place and is not always an integral part of the lesion, a view partly sustained by an examination of the autopsy records; for many of these protocols fail to mention or describe the size or appearance of the duodenum. It is manifest that this evidence is of no moment, because post-mortem examinations, particularly of patients who have died from surgical operations, are frequently incomplete and hasty. Indeed, many times, the autopsies are nothing, more or less, than superficial examinations conducted through the original operative incision, by an interne, to satisfy his natural and very creditable curiosity as to the cause of death. A fleeting view is obtained of the viscera and the essential point noted, but the vital details needed and requisite for a complete understanding of the disease are overlooked. It is a practice, admittedly, of scientific value but of extremely limited scope.

Another factor of extreme importance is that unless an autopsy is performed with extreme care, the position of the intestines may be disturbed and the actual state of the duodenum, which ordinarily is difficult to inspect, owing to its deep position and obscure anatomical relations, may be overlooked. Dilatation of the duodenum, therefore, which is not a distinctive condition, may be undiscovered, owing to the conditions present and prevailing at autopsy. Naturally, if the examining physician or pathologist has the lesion clearly in mind previous to incision, it is conceivable that special care would be taken to note the state of the intestine. There is no doubt but that rough handling and coarse manip-

ulation of the intestine, incidental to the autopsy, disturbs greatly the visceral relations. It is possible, when an autopsy is made, that slight alterations in the position of the abdomen may loosen the viscera, or even eliminate or obscure the obstruction. In view of this likelihood, the abdominal organs should be hardened *in situ*, and, at a later date, be carefully studied.

The term—arterio-mesenteric obstruction—is open to misconstruction, for it creates the impression that the artery is the constricting factor. Evidence exists, relating especially to the width and position of the pressing band or area of hyperæmia and necrosis on the wall of the duodenum, which tends to disprove this belief.

The persistent character of the duodenal obstruction is generally ascribed to the traction action of the stomach, which by virtue of its extreme weight and pressure displaces the entire small intestine and the pelvis, producing, as an indirect result, a distinct drag on the mesentery.

The term—acute dilatation of the stomach—is not complete or correct, because it fails to connote the dilatation of the duodenum, which is just as marked and, probably, the most important, or perhaps even the primary lesion.

In the ANNALS OF SURGERY, Doctor Cohn reported a case and the bibliography of acute dilatation of the stomach, secondary to trauma or infection of the extremities. He made a thorough search of the literature and was able to find but ten authentic cases in which acute dilatation of the stomach followed injury, infection, or an open operation of either the upper or lower extremities. It is evident, therefore, that the condition is extremely rare. In order to stimulate interest in this puzzling condition, the following case is reported:

A. M., age thirty-four, admitted to Fordham Hospital, December 30, 1916. Died March 15, 1917. The previous and family history of no moment. On December 30, 1916, while inspecting the overhead trolley wires of the New York Central Railroad at Williamsbridge, the patient made a contact with 1100 volts. The shock disturbing his balance, he fell from the cross-piece of the trolley pole to the ground, a distance of forty feet. When found, the patient was unconscious. He was quickly brought to the hospital. On examination, the patient proved to be well-developed, with large muscles. The eyes were equal; pupils contracted; marked subconjunctival hemorrhage of the left eye; lacerations of the left eyebrow, requiring four silk sutures, and slight abrasions of the face. He complained of pain in the chest. Auscultation revealed distinct crepitus over the fifth rib in the mammary line. Palpation showed no tenderness or false point of motion. Abdomen negative. The left leg was everted; marked swelling of the upper half of the thigh; patient could not raise heel from the bed; definite false point of motion, crepitus and tenderness elicited in the upper part of the left femur.

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Measurement disclosed one-half inch shortening. The patient received the general treatment for shock and the fractured limb was immediately immobilized in long, lateral, moulded, plaster splints. X-ray report by Doctor I. Landsmann, January 13, 1917: The radiographic examination of the left femur disclosed the presence of an intertrochanteric fracture of the neck of the femur, with an upward and outward displacement of the upper fragment. The great trochanter is again fractured from the upper fragment. There has also been a fracture of the horizontal ramus of the os pubis, with no separation of the fragments. No fracture of the ribs.

Diagnosis.—An irregular, comminuted, intertrochanteric fracture of the left femur; fracture of the pelvis.

January 4, 1917, the temporary dressing was changed. The patient's condition remained excellent. Dressings applied to the lacerated eye.

January 15, 1917, operation (Dr. Anthony H. Harrigan). Ether narcosis. An incision was made over the great trochanter and the site of fracture was exposed. Extreme difficulty was met in the attempt to secure reduction of the fragments. In order to obtain reduction, four small fragments had to be removed. Following this a Lane plate was applied, using four screws. The inner fragment, attached to the great trochanter, was sutured to the shaft-bone with kangaroo tendon. In order to maintain reduction and to retain the fragments in alignment, the limb was encased in plaster in the position of partial abduction. The patient withstood the operation very well. No shock or hemorrhage. About ten days following operation, however, temperature gradually rose. It was evident that the operative wound was infected. Daily dressings were instituted. Despite this the suppuration continued. The plate became exposed in the wound.

February 17, 1917, the patient was brought to the operating room and under ether narcosis, the Lane plate was removed, the incision was well opened, irrigated with iodine water and then packed with sterile gauze. The patient improved slightly following the removal of the plate. Temperature, however, continued and he complained of severe pain in the left knee-joint. A Volkmann splint was applied to prevent eversion of the leg. The femur was partly immobilized with sandbags. Daily dressings failed to relieve the pain in the knee-joint; the discharge, however, was not profuse.

March 9, 1917, the patient began to vomit at frequent intervals. The ordinary remedies were used for the first two days. These failed, however, to stop vomiting. Stomach washes, gastric lavage, was then instituted. The vomitus was a dark greenish fluid and of large amount. The temperature which had been elevated became subnormal and continued so until his death. The patient vomited every day from this time until the 15th, the day of his death. After each attack of vomiting the stomach was washed. He complained absolutely of no pain, whatsoever, during this stage. Hypodermoclysis 500 c.c. given every eight hours. Patient was placed on a

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Bradford frame with the view of immobilization of the limb, with a minimum amount of discomfort to the patient from dressings and lifting. During the night of the 9th, he complained of pain in the gastric region; nausea and vomiting. Large amount of light brown fluid with curdled masses. Morphine and bismuth given.

March 10, 1917, patient seemed slightly relieved. He soon, however, vomited a large amount of dark brown fluid. Stomach wash. Patient very weak. Hypodermoclysis saline solution, 500 c.c., every eight hours. Gastric lavage.

March 12, 1917, the patient was removed from the Bradford frame. Vomited during the entire day, greenish fluid. Patient very weak. Hypodermoclysis saline solution, 500 c.c., every eight hours. Murphy drip and digalen. Continued to vomit at intervals, small amount of greenish-black fluid. Restless.

March 13, 1917, vomiting still continues. Gaunt. Face pinched. Vomits continuously. Has been removed from the Bradford frame. Temperature still subnormal. Hypodermoclysis continued. Gastric lavage. Patient very low. At night vomited amount of greenish-black fluid, about six ounces.

March 15, 1917, condition low. Digalen and hypodermoclysis. Vomited small amount of greenish-black fluid. Patient very weak. Unconscious. Pulse thready. Died at 8.50 P.M.

On this day, visible peristalsis was distinctly seen when the abdomen was flicked with the finger. A central protuberance would slowly form; left to itself, it seemed to disappear by vermicular movements. The movements appeared to be unmistakable and absolutely indicative of acute dilatation of the stomach. As the urine continued in abundant amount and proved negative on examination, uræmic poisoning was excluded as the cause of vomiting. A septic embolus of the brain, likewise, owing to the absence of distinctive head symptoms. Moreover, the temperature was depressed and the signs of general sepsis lacking. Diagnosis: Acute dilatation of the stomach.

URINALYSIS

December 31, 1916.—Transparency, cloudy; reaction, acid; casts, 0; erythrocytes, —; color, amber; albumin, 0; leucocytes, 0; amorphous sediment, flocc. ppt., specific gravity, 1030; glucose, 0; pus, 0.

January 16, 1917.—Transparency, clear; reaction, acid; casts, granular cylindroids; erythrocytes, 0; color, amber; albumin, faint trace; glucose, 0; leucocytes, pus, few; amorphous sediment, 0; specific gravity, 1020.

January 21, 1917.—Transparency, clear; reaction, acid; casts, 0; erythrocytes, —; color, amber; albumin, 0; leucocytes, pus, few; amorphous sediment, flocc. ppt., specific gravity, 1020; glucose, 0.

February 18, 1917.—Transparency, cloudy; reaction, acid; casts, 0; amorphous sediment, 0; color, amber; albumin, trace; leucocytes, 0; specific gravity, 1020; glucose, 0; erythrocytes, 0.

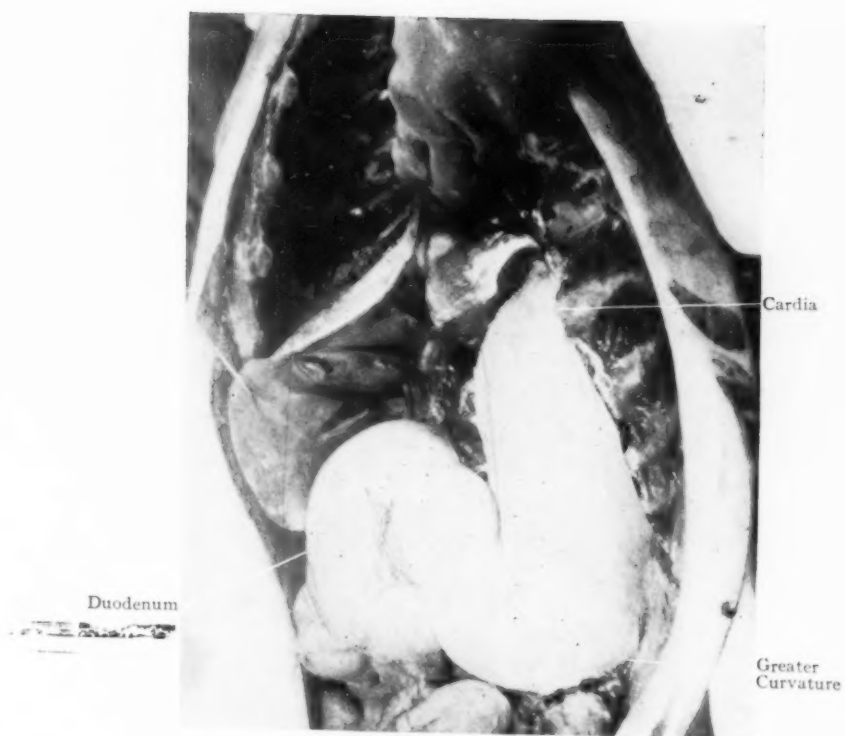


FIG. 1.—Showing tremendous enlargement of stomach and duodenum.

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BLOOD EXAMINATIONS

January 19, 1917.—Leucocytes, 22,200; polynuclears, 97 per cent.; number cells cnt., 100; lymphocytes, 3 per cent.

January 21, 1917.—Leucocytes, 8200; polynuclears, 68 per cent.; number cells cnt., 100; lymphocytes, 32 per cent.

February 8, 1917.—Leucocytes, 9800; polynuclears, 76 per cent.; number cells cnt., 100; lymphocytes, 14 per cent.

February 11, 1917.—Leucocytes, 9600; polynuclears, 81 per cent.; numbers cells cnt., 100; lymphocytes, 19 per cent.

February 15, 1917.—Leucocytes, 11,000; polynuclears, 83 per cent.; number cells cnt., 100; lymphocytes, 17 per cent.

February 20, 1917.—Leucocytes, 11,200; polynuclears, 82 per cent.; number cells cnt., 100; lymphocytes, 18 per cent.

February 25, 1917.—Leucocytes, 11,000; polynuclears, 81 per cent.; number cells cnt., 100; lymphocytes, 19 per cent.

Autopsy (Dr. George Hohmann), April 4, 1919, 11 A.M. Body is that of a man, 5 feet 8 inches in height, weighing about 130 pounds; very much emaciated. Abdomen retracted. Bed-sore on each buttock. Left leg was about four inches shorter than right. An open incision with drain inserted was noticed in the region of the right hip (result of previous open operation for reduction of fracture).

Usual incision from supersternal notch to pubes. Abdominal examination: The undisturbed viscera showed the stomach and duodenum greatly dilated, the latter extending to a point anterior to the vertebral column. Beyond this point the remainder of the intestinal tract was normally inflated. The transverse colon was displaced downwards a distance of two or three inches. Position and size of all other viscera appeared normal, except spleen, which was pushed upwards about one inch. Examination showed a tremendous distention of the stomach (Fig. 1). The duodenum was also greatly dilated, up to the point where it was crossed by the superior mesenteric artery. The surface of the duodenum presented a peculiar mottled appearance, causing it to greatly resemble pancreatic tissue. The superficial veins were distended. The stomach was grayish-white in color. It resembled a large ovarian cyst. The first part of the jejunum was normal in size and appearance. There was no free fluid present in the abdomen and no signs of peritonitis. The pylorus was distinctly patent. The stomach and duodenum showed no evidence of ulceration or carcinoma. The stomach lay in a vertical position, with the pylorus forming a short hook, similar to the end of a hockey stick. The creasing or the obstruction of the terminal duodenum by the superior mesenteric artery was clearly seen. The dilatation of the stomach and the duodenum extended precisely to the point of crossing of the superior mesenteric artery. The duodenum immediately distal to this point was absolutely normal in calibre. The duodenum was of the "U" shaped type and its various anatomic divisions could be clearly identified. As the transverse colon was not distended, its relation to the duodenum was distinctly evident. The autopsy showed no signs of sepsis or evidence of pyæmia. The cardiac sphincter was closed, but the pyloric was open and much dilated. The duodenum was dilated and its wall thinned. This dilatation extended to a point anterior to the vertebral column, where the duodenum was crossed by the superior mesenteric artery, the latter producing indirect pressure at this point and causing partial, and, indeed, almost complete, constriction of the intestinal lumen. The duodenum to the left of this was displaced downwards a distance of two or three inches. Position and size of antrum or calibre. Size of stomach, 23½ cm. long; diameter, 11 cm.; at pylorus,

6x3¼ cm.; duodenum, 14 cm. long, 5x6 cm. diameter. Liver, spleen and kidneys negative. Chest examination: Right lung was covered with a number of old pleural adhesions; lungs otherwise negative. Heart and pericardium: On gross examination, appeared negative. Head: Brain and membranes negative.

Microscopical Examination: The mucous membrane of the stomach showed a moderate round-celled infiltration, with congestion, but there were practically no other changes visible. In the duodenum a similar inflammatory infiltration is present, extremely marked in circumscribed areas, where the polymorphonuclear cells are massed together. The submucosa is slightly infiltrated. The muscularis shows no changes.

In passing, however, it may be pertinent to point out that one predisposing etiological factor was present—an alteration in the posture. The symptoms began soon after using the Bradford frame. The vomiting developed following his being placed on the Bradford frame. The evening of the first day he complained that the sharp edge of the canvas, at the upper margin of the hole cut for defecation, pressed and cut him. The nurse, therefore, took the lower end of the frame from the end of the bed and placed it on the mattress. The upper end had rested on sandbags, placed at right angles, to secure a solid support. These bags were lowered, but not removed. This resulted in the frame being placed in a moderate degree of inclination, a point overlooked by the nurse. The following morning, when visiting the patient, it was found that as a result of the inclined position, he had slipped down the frame, so that the buttocks lay in the hole. The vomiting occurred immediately after this. This slight reversed Trendelenburg position may have permitted the small intestine to sag downward into the pelvis and to drag on the mesentery.

In the case which is detailed, it is interesting to recall the actual conditions preceding the development of this lesion. In a patient suffering from an infected wound, of moderate severity, acute dilatation of the stomach develops to an extreme degree. Profound toxæmia occurs and death takes place. But many days had elapsed since the administration of the anæsthetic. It is impossible to ascribe this case to the excretion of ether or chloroform into the stomach. The sole etiologic fact in the history is the rapid occurrence of acute dilatation following the placing of the patient on a Bradford frame.

This incident, which would place this case in the category described by numerous authors, as following spinal scoliosis, kyphosis, etc., is strikingly similar to the case in which acute dilatation of the stomach developed, following the application of a plaster-of-Paris jacket, to a patient with scoliosis. The sliding of the patient, with the buttocks projecting into the opening in the canvas, produced a marked bending of the spinal column. This acute lordosis, if the expression be permitted, was rapidly followed by the development of acute dilatation of the stomach. It is needless to state that this etiologic factor, the alteration in posture, merely offers, as it were, a mechanical preparation and could

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not be the actual cause. The specific causal element is, no doubt, more profound and physiological.

In order to record another case, but one, I believe, to be of an entirely different nature, the following history is recorded:

The patient came under my observation in Fordham Hospital, January 15, 1918. The operation performed was a Gilliam suspension. At the conclusion of the operation, which had proceeded smoothly and without hindrance, I noticed the stomach bulging into the wound. The incision was about four inches long and situated midway between the os pubis and the umbilicus. The stomach was intensely engorged. Its color was brown or mahogany. The blood-vessels on its surface were deeply injected. To the exploring hand the stomach felt like a large cyst and it appeared to be at least five times its normal size. I could detect no evidence of a pyloric or duodenal kink, or cicatrix. The greater curvature, when the stomach was at its maximum distention, was but four inches from the os pubis. The stomach rapidly collapsed and at once returned to its normal size following the introduction of a stomach tube. At no time during the operation was the swallowing of air detected. This point was corroborated by the anæsthetist.

A second case occurred at St. Francis Hospital, when I operated on a young married woman for chronic appendicitis and salpingitis. During the operation, the stomach presented into the wound. At the time of maximum distention, the greater curvature measured two inches from the os pubis. Nothing noteworthy occurred, save that during the induction of narcosis, the patient became cyanosed and the tongue was forcibly pulled forward.

The personal case of Lee was one of acute dilatation taking place during an operation (gastro-jejunostomy) for duodenal ulcer. Death took place at the end of the operation. He describes in detail other instances in the literature of acute dilatation of the stomach occurring during the actual performance of an abdominal operation. Lockett's case is striking, in that the patient was observed swallowing air. This places some of these cases in a peculiar classification and tends to separate them from the other group. To my mind, we are dealing with a condition which is fundamentally and radically different from acute dilatation, which occurs in the course of acute infections, as a post-operative sequel, or as a result of a disease or injury to the extremities. It is possible that this type of dilatation results from a difference of intra-abdominal and atmospheric pressure. This conception is purely theoretical. When the abdomen is opened and the air enters the peritoneal cavity, the cardia sphincter may relax and the air, normally present in the œsophagus, passes rapidly into the stomach, until the pressure—*intra* and *extra* gastric—is equalized. This view is worthy of consideration and experimentation.

The study of the gross pathology of acute dilatation of the stomach is incomplete. More information is desired concerning the question of equal involvement of the anterior and posterior walls of the stomach. Also, the relation of the transverse colon to the dilated stomach needs clarification. The cases in which a definite physical obstruction at the pylorus has been described are, probably, not true instances of acute dilatation of the stomach. Though several writers speak of rupture of the muscular layers and of minute hemorrhages in the mucous and sub-mucous layers, the histology remains obscure. Conner found that thirty-eight per cent. of the cases had a part or whole of the duodenum dilated. In this connection, one must again point out that it is possible, owing to hasty investigation, or lack of care on the part of the examining physician, the actual appearance and calibre of the duodenum may not be accurately noted. Moreover, the precise point at which the dilatation ceases is not known. In many of the analyzed cases, the dilatation ceases where the duodenum is crossed by the mesentery, a distinct ring of necrosis existing at this point. In three cases, the dilatation involved the beginning of the jejunum.

A noteworthy point mentioned in the sixty-nine autopsy records collected by Conner is the large size of the stomach. In numerous cases the greater curvature reached to the symphysis pubis. The color of the stomach may be purplish-red, gray, or bluish-white. Some writers describe a characteristic cylindrical form, producing a more or less "U" or "V" shaped organ. An interesting group of cases is associated with disease or injury of the spinal column. These instances have been associated with disease and deformity of the spine, particularly Pott's disease, with dorsal kyphosis, uniform kyphosis of the whole dorsal and lumbar regions, dorsolumbar scoliosis and rachitic dorsal kyphoscoliosis.

From the clinical and analytical viewpoint, the theory of primary mesenteric occlusion of the duodenum has been widely discussed. At the point of intersection of the mesenteric root and lower duodenal segment, there exists, even under normal conditions, a constriction, which, as a result of distention of the stomach and duodenum, becomes more distinctly manifested. A major part of the discussion centres round the relationship of the superior mesenteric artery to the terminal duodenum. Conner, as a result of his anatomical studies, finds this condition common. Moreover, the case of the author aptly illustrates this point. This important anatomical finding naturally has led many observers to consider acute dilatation of the stomach an obstruction, caused by the superior mesenteric artery constricting the terminal duodenum. The frequency of its occurrence has strengthened the conclusion.

Conner supports the theory of mesenteric obstruction. He concludes that it is frequently found, according to autopsy records, and that enormous quantity of fluid vomited, or obtainable by lavage, indicates high

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obstruction. The high obstruction prevents the usual reabsorption of the stomach, liver and pancreatic secretions.

Facts elicited at autopsies must, however, be subjected to strict scrutiny. One should recall that autopsies, particularly in surgical cases, are often done hurriedly, perhaps through the original operative incision, owing to failure to obtain consent for a complete examination. Furthermore, they are frequently performed by internes, whose sole desire, in contradistinction to the trained pathologist, is to find or establish one definite point.

Conner made special anatomical studies to solve these problems. After moving the entire small intestine and attaching a cord and weight to the mesentery, he filled the stomach with tap water, in order to determine the degree of pressure to overcome the duodenal obstruction. The observations, though subject to inherent errors, appeared to prove that traction of the mesentery can produce obstruction of the duodenum, a view previously advanced by Albrecht. It is necessary, however, in this theory, to grant the postulate that the small intestine falls into the pelvis. The question as to whether changes in the abdomen favor the descent of the intestine into the pelvis is not understood.

Conner believes that the most common cause is the constriction of the duodenum produced at the base of the mesentery by the superior mesenteric artery. Moreover, he expressly states that, in his opinion, for the constriction completely to prevent the passage of fluid and gas, it is necessary that the small intestine lie, mainly, in the pelvis. Unquestionably, this added qualification greatly weakens the original force of the arterio-mesenteric theory. In short, the obstruction must be complete before dilatation occurs. It is evident that the traction of the mesentery would be immeasurably increased were the small intestine in the pelvis. The crucial point in the discussion is, does the small intestine lie in the pelvis? No evidence exists to prove this. The post-mortem records are hardly admissible, because they fail to present the actual conditions occurring during life. The position and arrangement of the small intestine unquestionably depend, to a great extent, upon the amount and nature of the intestinal contents and the degree of tonus. Without a precise knowledge of these factors, it is impossible to come to a logical conclusion regarding the actual dragging or traction of the small intestine.

There has been some minor discussion as to whether the constricting element is the mesentery or the artery. The evidence consists, mainly, in the width or area of the affected duodenum. The weight of opinion is that it is caused by the root of the mesentery. Some adherents of the mesenteric theory resort to subsidiary theories in order to explain the permanent nature of the obstruction. They maintain that the stomach, becoming distended, descends and compresses the duodenum.

Extensive experimental investigations have been made by Kelling, who initiates his research on the assumption that dilatation of the

stomach cannot occur if the stomach retains the power of contraction, over-distention being avoided by the onward or upward propulsion of the contents. A valvular closure of the duodenum, the result of a slight kink, may follow artificial distention, pathological adhesions predisposing to this form of kinking. Though the kink usually lies above the opening of the common bile duct, it may lie below. In the latter instance, the bile and pancreatic secretions are found in the stomach contents. Kelling is extremely enthusiastic in the defense of the theory, but the experiments appear somewhat crude, and in no manner comparable to the mechanism of the living stomach. Furthermore, he fails to mention the details and technic of the inflation method and does not state succinctly whether the condition occurs so rapidly that the stomach or intestine is unable to withstand increased pressure, or whether a distention so sudden is possible during life. The inflation, naturally, would have to overcome the normal tonus of the intestine, an effort which would require a high degree of air pressure. Kelling believes that there are individuals in whom spontaneous occlusion of the cardia and of the duodenum occurs from over-distention of the stomach and that this leads to acute dilatation. Fermentation forms an important auxiliary factor.

As the literature records numerous cases in which the greater curvature reached the symphysis pubis, Kelling stresses gastropexia, especially the low position of the cardia, as an important predisposing factor, and one possibly explaining the tendency to valvular closure of the cardia. He believes, also, that a low position of the pylorus, or pyloric stenosis, local peritonitis in the region of the pylorus and the duodenum, and especially narcosis, predispose to kinking of the duodenum. While Kelling does not support the theory of arterio-mesenteric obstruction, he believes that a distended stomach may push the small intestine into the pelvis, creating secondary arterio-mesenteric obstruction. This opinion is qualified, however, by adding that arterio-mesenteric obstruction may, at times, be primary and the kinking secondary. In a series of cadavers, he inflated the stomach through an opening in its anterior wall and found that the cardiac orifice possessed a modified valve-like action, which prevented the air from passing into the œsophagus; but, when the intragastric pressure was markedly increased, the air freely passed into the œsophagus. After ligating the œsophagus and inflating the stomach, air passed freely through the duodenum; but, in certain instances, an obstruction occurred from the formation of a sharp kink. This kink occupied various levels of the duodenum. As a result of these investigations, Kelling contends that acute dilatation of the stomach occurs in individuals who possess a tendency to cardiac valvular closure and the production of an obstructive kink in the duodenum. Conner, in repeating these experiments, failed to find the obstructive kinks so distinctive or frequent. Kelling made additional experiments in dogs. Through a gastrostomy incision, acute dilatation of the stomach was produced by inflation. When a certain degree

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of distention was attained, vomiting resulted and the dilatation was relieved. If the animal were narcotized, the stomach could be distended to the bursting point, without the least escape of air through the œsophagus, or without any reflex attempt at vomiting. In an experiment mentioned by Braun, a dog, with a previously made gastrostomy, had the vagi cut in the neck. Twenty-four to forty-eight hours later, he inflated the stomach through the fistula. Nevertheless, the animal was capable of emptying the stomach through vomiting. This experiment, beyond proving that the vagus does not necessarily play a part in the vomiting, or nervous activity of the stomach, has no physiological significance. Moreover, any experiment employing general anæsthesia introduces the influence of narcosis upon the act of vomiting.

Spasm of the pylorus is believed by some to be the essential factor. A superficial review quickly dispels this view, for the pathological records of acute dilatation of the stomach prove positively that the lesion does not stop at the pylorus; moreover, the presence of the contents of the upper intestine in the vomitus demonstrates conclusively that the stomach and the duodenum freely communicate.

Cadaver experiments are fallacious. The physical conditions differ so greatly that all comparisons and distinctions are lost and the reasoning inevitably becomes illogical. In a cadaver the stomach is lax, toneless and consequently shapeless. It must follow that experiments performed in order to determine the tonicity and condition of the sphincters are valueless.

The relation of the sphincters, to the specific cause, has been widely discussed. No doubt the sphincters, both cardiac and pyloric, play a part; but one, unquestionably, contributory and not specific. Kelling, Seidel and Conner conducted experiments in order to determine the rôle played by the cardiac and pyloric sphincters. Their results were indefinite and uncertain. Braun and Seidel state that opening the abdomen caused a cardiac contraction. But it is evident that reflexes may be engendered during the experiment, which may easily alter and affect the normal degree of contraction.

Some authors have laid great stress upon the fact that acute dilatation of the stomach generally follows narcosis. Unquestionably, both ether and chloroform are excreted by the gastric mucous membrane; but, in the unusual cases, particularly that furnished by the author, the interval of time elapsing between the administration of the anæsthetic and the onset of dilatation is so long, in many cases extending over weeks or months, that it seems impossible to establish a specific etiologic relationship.

The subject of high intestinal obstruction received a new impetus from the experimental investigations of Draper. This author, while studying the technic of the triangular twine suture in gastro-enterostomy, noticed that the animals died before the ligature cut through. From this crucial experiment evolved a long series of experiments, which he has

collected and collated in several distinctive papers. In sum, Draper concluded that there was a definite form of high duodenal obstruction which resulted in death from a chemical cause. From this point other investigators, namely, Whipple, Hartwell, Sweet, etc., have conducted subsidiary experiments, mainly, with the view of determining whether the cause of death in high duodenal obstruction was essentially chemical or bacterial. To amplify the latter statement, one means, of course, by chemical origin, that death was independent of the growth of bacteria in the body.

Hartwell and Hoguet conducted a series of experiments on dogs to determine the cause of death in intestinal obstruction. The post-mortems were carefully conducted, all tissue being examined microscopically. Blood and organ cultures were made. They concluded that death is not due to a bacterial infection. Their experiments are somewhat diffuse in that they worked indiscriminately on various parts of the intestine. An important technical advance mentioned is the use of a special clamp to occlude the intestine. They state that transverse division and inversion of the ends produce inflammatory alterations in the walls of the intestine, which vitiate the results and disturb the accuracy of the observation. Hartwell, in insisting that strangulation adds a disturbing factor to the problem, endeavored to eliminate it by devising this special occluding clamp. Simple division and inversion of the ends, according to his view, may produce a local strangulation. Furthermore, he states that at autopsy, there is found a structural change in the wall of the intestine, sufficient in extent to admit a ready absorption of the poison, a point from which he bases his divergence from Whipple.

Sweet has concisely summarized the experimental work of Whipple and Draper, investigators who have studied diligently the cause of death in high intestinal obstruction. In point of fact, Draper was the first to show that high division of the duodenum caused death. Whipple believes that a toxic protease is the lethal agent. Though Sweet concurs, he suggests that, possibly, the pancreatic secretion plays a part in the production of the protease.

Hartwell appears as an opponent of Whipple, Stone and Bernheim in maintaining that the poisons isolated by these authors result not from the activity of the mucosa, but occur as a result of injury to the intestinal wall, consequent to the unavoidable operative trauma and manipulations. In this connection, it is interesting to recall the criticisms of Sweet, who points out that Whipple, in his study of a closed loop, was, in reality, dealing with high intestinal obstruction as practiced by Draper; and that it is not unreasonable to assume that the duodenal poison is secreted into the closed loop.

It is definitely known that the intestine normally contains microorganisms potentially pathogenic and that their activity and virulence are augmented during obstruction. Also, that bacteria may migrate

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through the wall of a congested or injured intestine. It is not clear, however, whether bacteremia may occur, unless there be a primary peritonitis, though it is conceded that strangulation greatly favors the migration of bacteria. The experiments of Hartwell apparently prove that death is not caused by bacterial infection. He inclines strongly to the theory of dehydration. For one to keep this clinical picture in mind, he is impressed by the great similarity which it bears to that presented in experimental high ligation of the intestine in animals.

Indeed, from the experimental studies of Draper, Whipple and Sweet, it would appear definitely proved that a toxic proteose is the actual lethal agent in high intestinal obstruction. This is true provided peritonitis does not occur, for in this case infection is the determining factor. It is possible that the pancreatic secretion plays a part in the production of the toxic protein. In point of fact, the symptoms of acute pancreatitis are strikingly similar to those of high duodenal or jejunal obstruction, and it is a generally accepted belief that the intoxication in acute pancreatitis results from toxic bodies engendered during production.

The intoxication theory has been approached by injecting the normal contents of the stomach and the intestine, and the injection of the intestinal contents oral to the site of the obstruction. Naturally, this material contained bacteria. It is assumed, however, that the rapid death excluded bacterial infection. The conclusion is that the injection of these contents causes death. These experiments are extremely crude. The chief objections to the intoxication theory are based on the dissimilarity of the symptoms of acute intestinal obstruction and those following the injection of the intestinal contents into the blood; the lessened absorbing power of the obstructed gut; and, that many bodies, for example, peptone, if injected into the blood are lethal, while if placed in the intestinal tract are innocuous.

The cardinal point is that death is a chemical one. Moreover, if the ligation of the duodenum is made at a point more than 35 c.c. from the pylorus, death is obviated. The question intimately concerns the activity of the proteolytic enzymes of the pancreatic juice of the succus entericus. Also, one must consider the activity of a lipase capable of breaking down lecithin into neurine and choline which are highly toxic bodies.

Leaving this question aside, for the moment, of the cause of death, there is, unquestionably, a striking similarity in point of symptoms, between acute dilatation of the stomach and high duodenal obstruction, as seen in animal experiments. This view, a personal one, was acquired from a series of experiments on cats, conducted by the writer, under ether narcosis, in which the upper intestine immediately below the pancreas was ligated with plain tape. In these experiments, an effort was made to determine the effects of the hypothetical poison of high duodenal obstruction on the ganglion cells of the myenteric plexus. This, necessarily, included a study of the spinal cord and the peripheral nerves,

the vagus, sympathetic and splanchnic. These were to be studied from the histological and physiological aspects. Of course, in performing these animal experiments, the element of asphyxia was considered in the production of abnormal contractions.

Stimulated by the experimental investigations of Keith and Alvarez, the writer formed a hypothesis to explain the mechanism of acute dilatation of the stomach. The hypothesis consists merely in the assumption that acute dilatation of the stomach is caused by paralysis, inhibition, or failure of function; and, that this paralysis, inhibition, or loss of function is toxic in origin. This hypothesis rests upon the assumption that there exists in the wall of the duodenum, a nerve plexus which is capable of acting like a nodal centre; from which arise the impulses that initiate the degree and extent of peristalsis of the duodenum. Assuming this, a series of experiments on cats were conducted in order to determine if intestinal obstruction could produce anatomic alterations in the myenteric plexus. In these cats and a few dogs, following ligation of the duodenum immediately below the border of the pancreas, symptoms developed in all instances as described by previous workers in this endeavor. At the death of the animals, the duodenum and stomach were removed and subjected to histological investigations. In general, these results have been indefinite, owing to the technical difficulties offered to the histologist.

But it was extremely remarkable in studying the course of intestinal obstruction in these cats, to note that the general symptoms, so uniformly accepted and supposedly characteristic of acute intestinal obstruction, such as pain, and prostration, were generally lacking in these animals. These observations strengthened the belief that strangulation is, unquestionably, the dominant factor in the production of the acute or dynamic symptoms of intestinal obstruction. Another factor at play in the animal experiments is the question of ether, which may, possibly, modify or minimize the effects of the strangulation. In a word, a cat, in which intestinal obstruction has been produced under ether anaesthesia, the characteristic and usual symptoms significant of acute intestinal obstruction are lacking. The clinical picture observed in these animals resembles greatly that described by Draper as occurring in dogs. Instead of the clinical picture so often seen by the surgeon in occlusion, the clinical picture resembles that which is seen in acute dilatation of the stomach, where the occurrence of toxæmia is indisputable. There is no analogy, in the slightest, between the conditions observed and those seen in adults suffering from acute intestinal obstruction of the upper intestine. No pain appears evident. Whether this is due to the psychology and mental standards, or, perhaps, more likely to the influence of the anaesthetic, is not certain. Unquestionably, the element of strangulation is the determining one in the production of the intense and dominant symptoms of acute intestinal obstruction as seen in the human.

The problem should be considered from the newer conceptions and

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views of the physiology of the stomach and duodenum, a topic which, in recent years, has received additional stimulation from the suggestive work of Keith and Alvarez. These authors coincide fundamentally in their conceptions concerning the peristalsis of the stomach and duodenum. Keith, in particular, in emphasizing the striking analogy between the stomach and the heart, pointed out that both organs are developed from a simple muscular tube and receive a double nerve supply, and from this analogy assumes the existence of a definite nodal system in the intestinal wall, comparable to the neuro-muscular mechanism of the heart muscle. From the developmental viewpoint, the stomach and duodenum have a different origin than the small intestine. In a word, there is in the duodenum a meeting or fusing point between the fore and mid gut. It is possible to conceive a bundle of muscle connecting the two divisions of musculature, permitting the transmission of impulse or waves.

Without attempting a too intricate explanation or defense of the theory certain physiological points may be elaborated. The nerves entering the intestine form a plexus between the longitudinal and circular muscular fibres, called the intramuscular, or myenteric plexus of Auerbach. From this plexus, fibres pass obliquely through the circular muscular layer, in order to form within the submucous layer, the plexus of Meissner, from which branches pass to the villi to supply the glands. The plexus of Auerbach has definite microscopic ganglia.

The exact physiology of the intestinal muscles is unknown. Two theories exist, as in the case of the heart; one, the myogenic, the other, the neurogenic. The same anatomic basis for the theories and discussion likewise exist here, as in the case of the heart. It is generally assumed that the rhythmic movements are myogenic in origin, while the highly coördinated movements are dependent upon the intrinsic nervous system. The activity of the intestine, as a whole, is, probably, dependent upon the integrity of the myenteric plexus.

The so-called myenteric reflex, or law of the intestine, a principle discovered by Starling, is of interest in this connection. The anatomic basis of its mechanism depends upon the integrity of the myenteric plexus. Bayliss and Starling also proved that the law of the intestine maintained, even when all the nerves, from the central nervous system to the intestine, had been cut. An histologic experiment by Meek tends to confirm this view. In this experiment, Meek, following division of the intestine, studied the time of regeneration and proved that the myenteric reflex reappeared only when the regeneration of the intrinsic nervous apparatus was complete. These experiments tended to prove that the basis for this reflex existed, in all probability, in the plexus of Auerbach. Gaskell states that Kronecker and Meltzer, in their investigations of the peristaltic contractions of the œsophagus, antedated the later work of

Bayliss and Starling, who by means of the enterograph confirmed and recorded the law of the intestine.

Later experiments were made by Magnus, who studied an isolated piece of intestine suspended in Ringer's solution. After the two layers of muscle, longitudinal and circular, were separated by means of a needle, spontaneous movements occurred only in the longitudinal muscles. The circular layer remained quiescent. Upon stimulation, it gave a local contraction, but no signs of a contraction wave. In order to verify these observations, he made an histologic examination and found that the whole of the plexus of Auerbach was attached to the segment containing the longitudinal muscles. From this he agreed with Bayliss and Starling that the plexus functions after its complete separation from the central nervous system. From this one may assume that the myenteric plexus plays a dominant part in the peristalsis and tonus of the intestinal musculature. The plexus of Auerbach acts somewhat like an independent nervous system. Embryological researches, however, prove that it results from an outgrowth of cells of the spinal cord. Bayliss considers the plexus of Auerbach as the seat of the reflexes of peristalsis.

The smooth muscle fibres which compose the musculature of the sigmoid, like all non-striated muscle fibres, have the power of originating contraction, and according to Keith, the initiating impulses are collected and correlated in certain neuromuscular nodes. Failure of coördination of these in that centre is supposed to result in a most curious and interesting phenomenon, the so-called idiopathic dilatation of the colon, or Hirschsprung's disease. Many instances of this condition have been recognized since the attention of American surgeons was called to it by Finney. The disease is similar in origin to cardiospasm at the cardiac orifice, pylorospasm and stasis at the ileocaecal valve.

The question of whether the duodenum is indispensable to life and whether it has specific physiological functions, is still unsolved. An obstacle in the decision of these problems is the technical difficulties offered to the experimental surgeon in the removing of the duodenum. The relation of the pancreas and the stomach, and the question of the pancreatic and biliary ducts, increase the scope of the surgical and technical problems. Years ago Pfluger stated that when the duodenum is removed diabetes occurs. More recent investigators report that this contention is unsound. On the other hand, some maintain that the duodenum is as necessary to life as the suprarenals or the parathyroids. In a recently reported experiment, a dog was kept alive for three months after complete removal of the pyloric end of the stomach, the duodenum and the upper jejunum.

Acute dilatation of the stomach has been explained as a paralysis or inhibition of the nerve centre, either peripheral or central. If local, then its occurrence following operations on the gall-bladder is easily explained. The general and customary improvement in distention, following the

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removal of the drain, is explained by the relief of irritation of the local nervous mechanism in the bowel wall. But, among the numerous theories advanced to explain the cause of death in intestinal obstruction, is one ascribing the central nervous system as the primary factor. The dominant symptoms, rapid pulse, ataxia, low blood-pressure and dilatation of the splanchnic vessels, point suggestively to an involvement of the medullary centres. It is comparatively easy to state that the patient's condition is caused by paralysis of the stomach and duodenum. A closer analysis, however, demonstrates that this statement possesses no scientific value, because paralysis is a general term and meaningless in itself. It is readily understood what is meant by the paralysis of a muscle, but the actual specific cause must be known before one could have a clear understanding of the subject. Many authors have viewed the problem as a simple paralysis of the stomach, a view which has received some support from the analogy the condition bears to intestinal paralysis, following abdominal operations.

But in the instances of paralysis occurring as a part of the processes of peritonitis, it is manifest that the phenomena of inflammation which take place within the structures of the wall of the intestines are, undoubtedly, the primary determining causes of paralysis. These changes are demonstrable. One readily can note the exudation, the swelling and the oedema, and it is logical to assume, from this macroscopic picture, that the myenteric plexus is destroyed or injured by the action of the toxins. Simple trauma, consequent to an abdominal operation, may effect results similar to those produced by inflammatory changes; but, in acute dilatation of the stomach, this theory does not, at least in all cases, play a rôle.

It is well known, as above mentioned, particularly from the experimental work of Carrion and Hallion, that division of the vagi, even at varying levels, causes dilatation of the stomach. (In passing it may be mentioned that division of the vagi below the diaphragm in dogs is an exceedingly difficult operation. Accidental opening of the cardia is likely. The vagi may be divided within the chest, but the mortality of thoracotomy in dogs is high.) And from these experiments it was deduced that possibly a toxin acting on the centres controlling these nerves might produce the same result. This view of the nervous origin of the disease is partially substantiated in that the lesion has been noted following injuries to the head and spinal column. Also, the cases complicating pneumonia are explained on the ground that the infection, possibly, through an associated pleurisy, extended to the vagi as they pass through the thorax. Unfortunately, in these recorded instances, no histological examination has been made of the nerves. Such an examination would, undoubtedly, elicit important corroborative points.

In passing, one may say that the view of paralysis of function is advanced to explain many physiological problems. One may recall that within recent years, it was urged and maintained with considerable

plausibility, that paralysis of the vaso-motor centre is the essential mechanism of shock. Recent knowledge, however, proves that this ready-made theory of paralysis generally does not suffice. The phenomenon of inhibition is signally neglected by the enthusiastic theorist.

In order to restrain undue speculation and theorizing, the pregnant observations of Meltzer should be recalled. He points out that the history of physiological experimentation records the inevitable propensity of investigators to ascribe, in a general sense, a failure of function, involving the activity of the nervous system, to exhaustion or paralysis. A classical example illustrating this instance is the theory of paralysis originally suggested to explain the action of the vagus on the heart. Indeed, the phenomenon of inhibition has been emphasized but comparatively recently. If we transfer this dualistic conception of the nervous system, paralysis or inhibition, to the subject of the stomach, one may, with a fair degree of reasonableness, ascribe the causative mechanism as inhibitory in nature, in place of exhaustion, depression, or paralysis.

The mechanism of the abdominal reflexes is not clearly understood. Inhibition, unquestionably, plays a large part in their production, a point demonstrated by Meltzer in his experimental and physiological investigations concerning the causation of shock. The problem is, admittedly, a complicated one, because of the intricacies of the peripheral and central nervous system. Primarily, the question concerns the question of the vagus and the splanchnic nerves; but, in addition, the activity of the so-called myenteric plexus increases the scope of the problem.

Conclusion.—There is in both stomach and duodenum an intrinsic nervous system which for the sake of simplicity is called the myenteric plexus. In various places it is so arranged as to form distinct nodes. This nodal system is supposedly the point where the impulses leading to peristalsis are initiated. At present there is no direct evidence to prove that marked alterations occur in the myenteric plexus as the result, or coincident with duodenal obstruction. A marked disadvantage lies in the absence of a technical measure which can actually reproduce acute dilatation of the stomach. Moreover, the animals best suited to these experiments, such as the cat and the dog, offer peculiar difficulties to the histologist in his efforts to secure suitable specimens for microscopic study of the myenteric plexus. From the standpoint of the histologist, the white rat is, perhaps, the best animal for this particular work; but, from the viewpoint of the experimental worker, the rat is particularly unsuitable for experimental operation.

The finding of anatomic alterations in the myenteric plexus would prove of value, that would practically constitute direct proof that the theories of Keith, regarding the nodal system, possessed a sound basis. This more recent knowledge of the stomach and duodenum should be taken into consideration in the study of the causation of acute dilatation of the stomach.

PYLORIC STENOSIS IN INFANCY *

BY FRANCIS OLCOTT ALLEN, JR., M.D.

OF PHILADELPHIA

SOME time ago I reported two cases of pyloric stenosis in infants before this academy. Since then I have operated upon seven additional cases, making nine in all. This is a sufficient number to arouse one's interest in this curious pathological condition and to justify some tentative conclusions in regard to it. The subject is receiving increasing attention in the literature, and a number of valuable reports have appeared, the latest by Green and Sidbury, in the current number of *Surgery, Gynecology and Obstetrics*, discussing in considerable detail our meagre knowledge of it.

It is generally assumed that the pyloric ring is congenitally abnormal, but no explanation is forthcoming as to its true etiology. It must also be assumed that the hypertrophied muscle is thrown into spasm by unknown factors. Otherwise it is difficult to explain the frequent remission of symptoms and the occasional recovery of a patient without operation. We have not even an assumption to explain the overwhelming preponderance of the disease in boys. Girls seem to be almost exempt. All of my cases but one were boys. Like intussusception, it occurs most frequently in breast-fed infants.

The babies are usually healthy at birth, well nourished, and well formed, and make a good start. Then in a varying number of days or weeks they begin to do badly, vomit after feeding and fail to gain. The doctor in charge is driven to change the food, and for a time they again do well. Then the symptoms return and the food is changed again. This may go on for several weeks, but, as a rule, there is a progressive loss in weight until operation must be done. Many cases have some fecal evacuations, showing that the pylorus is not entirely closed, some have no stools for days at a time. The vomiting is not the regurgitant type, so common when an infant's stomach is overfilled, but is propulsive and copious.

A few quotations from my notes will illustrate the histories of these babies.

(Six weeks old.) "Baby weighed over 10 pounds at birth and did fairly well for two or three weeks, though vomiting more than normal. Then began to vomit almost everything. Weaned and various feedings given. No stools for two weeks."

(Seven weeks old.) "Has not done well since birth. Insufficient breast milk. On various mixtures. Seven and one-half at birth—reached 8.2, now 7.1. Vomiting at times. Has stools."

* Read before Philadelphia Academy of Surgery, February 13, 1919.

Ten days later.—“Wet nurse has been tried, but baby has lost weight again, vomiting. Weighs but little over 6 pounds.”

(Six weeks old.) “This was a thirteen pound baby, now weighing 5 pounds 12 ounces. Vomiting almost everything though has some stools. Emaciated, has purpuric eruption.”

(Five weeks old.) “Under observation several days. Seems to improve some days, but on the whole does not gain. Weighed 6.9 at birth.”

(Two months old.) “Vomiting began when about one month old. Has lost weight, but is not emaciated.”

(Two months old.) “Breast fed at first, then various mixtures. Frequent vomiting since about second week. Seven and three-quarter pounds at birth, now 5 pounds. Looks badly.”

Histories such as these are presumptive evidence that the pylorus is not normally patent, and in themselves would justify laparotomy. Fortunately, the diagnosis is always corroborated by the physical examination. Sooner or later gastric peristalsis becomes visible. It is best seen when the baby is taking a feeding or soon afterward. In its struggle against the obstruction, the stomach becomes distended, filling the upper abdomen, and the peristaltic waves can be seen through the thin abdominal wall passing from the left costal margin to the right. Frequently, but not always, the tumor can be felt. Its position varies. It is to be looked for on the right side between the umbilicus and the ribs. In one of my cases it was found at operation deep down under the liver; in another the distention of the stomach had carried it into the right kidney pouch. In neither of these cases was it palpable before operation.

Operation should be done as soon as the diagnosis is fairly certain. The diagnosis is made by the pediatricist, and I have never seen a case until the symptoms were fairly characteristic.

In my first case, in December, 1916, I did a gastro-enterostomy. In the others I have split the tumor longitudinally down to the mucous membrane, as suggested by Rammstedt in 1913. This operation requires care to avoid opening the duodenum, for the apex of the tumor bulges into the duodenum, and in trying to make the division of the tumor thorough enough to relieve the obstruction, it is easy to perforate the duodenal mucous membrane. I made this mistake once. I put in two fine catgut sutures and no trouble resulted. This operation requires care, also, to avoid hemorrhage. The tiny vessels come from the inferior aspect of the pylorus and I have found that the nearer the superior aspect of the pylorus the incision is made, the less the bleeding. In my first operation of this kind I made the incision on the lateral aspect of the pylorus, the easiest place, and the baby died a few hours later with its abdomen full of blood. It is almost impossible to catch and tie the vessels, so that any manœuvre to avoid them is worth while. In the last two or three cases I have operated from the left side of the patient, in

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order to hold the pylorus more easily in my left hand, and make an incision in its superior aspect with my right. This is a decided gain in convenience.

In spite of these dangers in the operation, perforation and hemorrhage, the procedure is so simple, and can be done so rapidly that it is likely to supplant gastro-enterostomy. In fact, judging from the reports I have seen in the last year or two, it seems to have done so already.

Of my 8 Rammstedt operations, 2 died, a mortality of 25 per cent. Downs reported 35, with 23 per cent.; Gallie and Robertson 16, with 31 per cent.; Green and Sidbury 5, without a death. Scudder, Stillman, and Richter did 36 gastro-enterostomies with 13 per cent. mortality, a remarkably good record. My gastro-enterostomy did pretty well for a week, then died unexpectedly on the eighth day, from some undiscovered cause. My first death with the Rammstedt was from hemorrhage, as already described. The second death was my seventh case, a girl baby two months old, who had been vomiting since the second week. The condition was not recognized by the family physician and she was in poor condition when a pediatricist was called in and made the diagnosis.

I found a rather large hard nodular tumor, split it, and closed the abdomen. The baby did very well until the afternoon of the third day, when the respirations became weak, of the Cheyne-Stokes type, and death ensued quickly. The pulse remained good after the respirations began to fail. I do not know how to explain such a death. It was similar to the death of the gastro-enterostomy case. Enlarged thymus, acidosis, and other vague causes have been discussed.

In addition to these cases of pyloric stenosis due to tumor, I want to report one case of a different form.

A boy baby seemed normal after birth and did well for a time, then began to vomit and lose weight, and finally gastric peristalsis became visible. A diagnosis of stenosis was made by the family physician and consulting pediatricist, and I concurred.

I operated when the baby was three months old. Instead of the usual tumor, I found a distinct plication at the pylorus, the duodenum bent forward and adherent to the stomach for a distance of almost a quarter of an inch. The area was hyperæmic and there were definite cobweb adhesions. I divided the adhesions with scissors, and straightened out the pylorus. It seemed patulous and I did nothing more but close the abdomen. The baby did not do very well for the first week, and the wound broke open. I closed it under an anæsthetic and inspected the pylorus, finding it apparently patulous and normal. Since then the child has done well.

CHOLECYSTITIS FOLLOWING TYPHOID FEVER IN CHILDHOOD*

BY HARRY C. DEAVEE, M.D.

OF PHILADELPHIA

SEQUELÆ of typhoid fever in childhood are not as common as in adult life. However, they are to be promptly recognized and combated when they do occur. This applies with particular emphasis in abdominal crises, that appear so suddenly, and are so rapid in their course.

The most frequent abdominal sequelæ to typhoid in childhood are perforation, hemorrhage and appendicitis, but the younger the child the less frequent is their occurrence. One of the most unusual conditions that would simulate them is cholecystitis.

Curiously enough, despite the fact that the gall-bladder harbors the *Bacillus typhosis* in large numbers after an attack of typhoid fever, cholecystitis is unusually an early sequel. It seems that the organism must be especially virulent, the individual lacking in resistance, and drainage poor, to set up an inflammation in the gall-bladder. When local infection does occur, however, it usually proceeds rapidly and an early perforation ensues. Diagnosis is usually made after perforation has taken place.

Keen's table,¹ added to by Erdmann,² contains adult cases chiefly, but Keen's nine cases under fifteen years of age, noted in the original table, have not been revised. Eight of these died, one recovering following an operation. All had perforations. The recovery noted was a case of Alexieff's,³ occurring in a five-year-old girl. The patient was doing nicely after her fifth or sixth week, when she had an attack of pain, rise in temperature, and was delirious. She was operated upon two days after the perforation occurred, and drained. Seven weeks later she had a recurrence and finally recovered.

The first evidence of abdominal pathology as a sequel to typhoid fever is pain. Pain should bring to mind at once the following: Distended bladder, diarrhœa, fecal impaction, constipation, intestinal obstruction, intestinal perforation, hemorrhage, appendicitis, iliac phlebitis, peritonitis, cholecystitis and pneumonia with pleurisy. An immediate examination will reveal other signs or symptoms that will point the way to a definite conclusion.

The localization of pain, if possible, in the upper right quadrant, radiating through to the back, tenderness and perhaps a palpably distended gall-bladder point to upper abdominal disease. Pneumonia should be carefully excluded even in the presence of very marked abdominal signs. Vomiting occurs, and the pulse rate goes up. Leucocytosis is present, 12,000 to 18,000, but may go well into the twenty thousands. The picture

* Read before the Philadelphia Academy of Surgery, February 13, 1919.

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is one of profound shock, and closely resembles obstruction, perforation, or a high ruptured appendix. Time will not always permit an exact diagnosis, nor should a prolonged effort be made to differentiate the type of abdominal catastrophe, for delay will militate against the patient's chance of recovery. Keen and Erdmann show that no cases recover without operation, and four of seven that were operated did recover. All had perforations. The statistics just quoted includes the nine children previously mentioned, and aggregates thirty-four cases. The case to be presented resembles Alexieef's closely in its inception and early course, but there the similarity ceases, except that both recovered.

H. S., aged five years, was admitted to the Children's Hospital of the Mary J. Drexel Home, September 10, 1917, with her two little sisters, aged four and two years and eight months, respectively. The three had typhoid fever, as did their father and mother. The mother was also pregnant and aborted during her illness. H. had a fever for about three days, but had been ailing for about ten days.

She had nose bleed, headache and indefinite abdominal pains. There was no vomiting. She was constipated. An enlarged spleen was manifest in a few days, and rose spots also appeared. Heart and lungs were negative for any pathology, as were the extremities. Leucocyte count was 8800, and she had two positive Widal's following a negative. The temperature on admission was 103.8° F. and went to 105° F. It stayed within this range for eight days, and then came down gradually, striking normal in six days. No untoward symptoms marred her apparent rapid recovery and gain in strength from the fourth of October until the twenty-second.

On the morning of October 22, H. vomited and complained of abdominal pain. The pain was generalized. She was given an enema with good result. Lavage did not give relief. The child was shocked, abdomen rigid and tender, the thighs flexed upon the abdomen. There was no distention and feeble peristalsis was present. The temperature was subnormal. Two hours after the first pain she was operated upon. Ether was given and an incision made through the right rectus muscle. A considerable quantity of serous fluid escaped from the peritoneal cavity.

When the gall-bladder was exposed it was markedly congested, slightly distended and had a dark area along the under surface of the fundus. There was no perforation. The gall-bladder was aspirated and a thick, dark, viscid, purulo-sanguinous fluid was removed. Moist pads were used to wall off the gall-bladder. The contents upon laboratory examination showed no typhoid agglutination, the Hay bacillus being found in the culture. The gall-bladder was drained with iodoform gauze. A piece of plain gauze was placed beneath and under the gall-bladder for drainage, and a fenestrated rubber tube was placed in the pelvis. The deeper layers of the abdominal wall were sutured with chromic catgut, silkworm gut in the skin.

The gauze was removed in five days, a small strip of plain gauze being replaced in the gall-bladder. A biliary fistula developed, which was subsequently closed and the child made an uneventful recovery.

Alexieef's case and this one both began with pain in the abdomen, in the course of their fifth or sixth week of typhoid fever. Both had similar symptoms, but his case went on with fever, chills and delirium, finally getting out of bed with consequent collapse. Operation after perforation did save the child despite a recurrence. My case was operated upon promptly and had no recurrence. While a secondary operation for the fistula was performed, it was not a dangerous procedure and the child did not have as rough a road to ultimate recovery as Alexieef's patient.

This comparative picture should show the advantage of careful attention to pain as an indicator of impending abdominal disaster. It should demonstrate the vital necessity for early surgery in an acute abdominal crisis.

Finally, while sequelæ are less common after child typhoid, when they do occur, they are more fulminating in their character, and always demand immediate attention.

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PRIMARY LYMPHOSARCOMA OF THE INTESTINES *

WITH REPORT OF TWO CASES

BY WILLIAM H. FISHER, M.D.

OF TOLEDO, OHIO

SURGEON ST. VINCENT'S HOSPITAL

SARCOMA may affect any portion of the intestinal tract. The combined reports of cases in the literature bearing on the subject are not so numerous as one would suppose.

In the report of the following two cases, one affected the ileum, the other affected the ascending colon. According to Forman,¹ "The order of frequency of the sites involved is ileum, cæcum, jejunum, appendix, transverse colon, sigmoid, duodenum, and descending colon. The frequency of sarcoma of the small intestine in the male compared with that of a female is, in the cases so far recorded, about 2 to 1. In the large intestine, according to Jopson and White, the frequency of incidence is nearly equal in the two sexes. According to Speese, the fourth, third, fifth, and second decades is the order of frequency of the ages afflicted with sarcoma of the small intestines. According to the reported cases the first decade has furnished the largest number of cases and the fourth decade stands next in the order of frequency for this site. As to whether syphilis bears an etiologic relationship to the development of sarcomata, there are all sorts of opinions from Schmidt, who remarks of sarcoma that luetic antecedents are not common, to von Esmarch, who states that in his clinic more than one-half of his sarcoma patients have been luetics. Kasemyer found in 284 cases of intussusception that a sarcoma had been the cause in 26 instances. Of the 74 cases of sarcoma of the small intestine collected by Speese, for which resection of the bowel was performed, 14 were also cases of intussusception.

"Sarcoma is even more infrequent in the large than in the small intestine. It is understood that the rectum is not included in this discussion. According to the tabulation of Jopson and White and Libman, the proportion between sarcoma of the small and large intestine is about two to one."

Bull² says, "Sarcoma of the intestine is rarer than carcinoma. The relation of these two tumors is about as 1 to 20. Sarcoma may involve either the small intestine or the large intestine or rectum, while carcinoma is far more frequently found in the large intestine and rectum. Krugerz Boas, who collected reports of 37 cases of sarcoma of the intestine, found the small intestine involved 16 times, the ileocæcum once, the cæcum twice, the vermiform appendix once, the transverse colon once, both the small and

* Read before the Academy of Medicine of Toledo and Lucas Co., Ohio, April 18, 1919.

large intestine once, and the rectum 16 times. Smoler reckons one case of sarcoma of the small intestine for every thousand autopsies.

"Sarcoma of the intestine may occur at any age, but most frequently between the thirtieth and fortieth years. Most of the cases reported have been in females. In Siegel's collection of 34 cases 19 of the tumors were round-cell and 5 spindle-cell. The other tumors were alveolar or melanotic cystosarcoma, lymphosarcoma, myxosarcoma, and endothelioma. Tuberculosis and sarcoma may coexist. Usually an intestinal sarcoma begins in the submucosa.

"Sarcoma of the intestine may reach a considerable size. In counter-distinction to carcinoma, it involves a considerable extent of the bowel and is much more likely to grow into the neighboring organs, especially the mesentery and omentum. Hence it is not always possible to say in which organ it began. It also sets up metastases in the liver, kidney, spleen, and retroperitoneal glands. In another respect sarcoma of the intestine differs from carcinoma; several writers have called attention to the absence of stenosis with sarcoma, and indeed, the lumen of the affected bowel may be considerably increased. There are, however, instances in which sarcoma has produced stenosis of a high degree. Siegel asserts that symptoms of stenosis occur in about one-half of the cases."

Keen³ in considering sarcoma of the small intestines says: "No case of this kind was observed in the Berlin Pathological Institute from 1859 to 1875. Smoler studied 13 cases occurring at Prague within fifteen years among 13,036 autopsies. Twelve cases, according to Nothnagel, occurred in Vienna between 1882 and 1893. The small intestine is most frequently the seat of these lymphosarcomata. In the large intestine they are much rarer, except in the rectum, where they occur as frequently as in the small intestine. Krueger gives the following statistics of 37 cases: The small intestine, 16; ileum and cæcum, 1; small intestine and colon, 1; rectum, 16. Baltzer states that 57.8 per cent. of the cases occur in the fourth decennium. Libman found among 42 cases, 15 involving the duodenum, 18 the jejunum and ileum, 14 the ileum, and 3 the entire intestinal tract.

"All microscopic varieties of sarcoma are observed in the intestine. Usually the neoplasm involves only the mucosa and the muscularis, the serosa being almost or quite free. In quite isolated cases the neoplasm took its origin in the serosa, and extended from there to the inner layers, the lymphosarcoma, which form the largest group, begin commonly in the submucous lymph-glands and grow along the axis of the bowel. The muscularis is early involved and paralyzed, permitting the fæces and gas to dilate the bowel. This intestinal dilatation is an especial, although not constant attendant phenomenon of lymphosarcoma of the intestine.

"The tumor may compress the vena cava, the biliary passages, the ductus pancreaticus, or the ureters. Ulceration is very frequent, and may lead to perforation either through an intestinal loop or into the abdominal



FIG. 1.—Tumor much contracted by preserving fluid. Now measures $17\frac{1}{2} \times 17\frac{1}{2} \times 12\frac{1}{2}$ cm. *a*, cæcum; *b*, distal end of ileum; *c*, cut surface of tumor; *d*, the opening of the cut transverse.



FIG. 2.—Posterior surface. *a*, retracted opening of transverse colon; *b*, cæcum.



FIG. 3.—Tumor cut open. Note central ulceration and necrosis of mass with hemorrhagic infarcts.

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PRIMARY LYMPHOSARCOMA OF THE INTESTINES

cavity. Metastases may also take place in various parts of the body." Jopson and White⁴ found 22 cases of sarcoma of large intestine. In 14 only was the growth confined to large intestine primarily. Three of these cases were confined to cæcum and ascending colon. Corner and Fairbanks⁵ collected 175 cases of sarcoma of the alimentary tract: œsophagus, 14; stomach, 58; small intestine, 65; ileocæcal, 20; colon, 11; rectum, 7. Sarcoma⁶ occurring in stomach according to recent statistics of Wild, Curlt, Tilger, Donath, Haberkant, Yates, and Lexer, in but 1 per cent., or at the most, 2 per cent. of cases, is an unusual condition. Hesse reports a case which has the added feature that the patient was in good health seven and one-half years following resection of about two-thirds of the stomach. Gosset, in reporting his case, found in the literature 171 cases, 21 of which had been overlooked by Zesas, or had been published since his monograph appeared. Gosset's patient, on whom a gastrectomy was done, was observed until a month and a half after operation, and at that time was doing well.

Metastasis is not as frequently seen as in carcinoma, but when it does occur, secondary growths are seen in the liver and in the neighboring glands, the mesenteric glands, in the kidneys, ovaries, lungs, and skin. The diagnosis is rarely made clinically, as the condition is so infrequent that one does not bear it in mind. There are no symptoms by which the nature of the tumor can be determined before autopsy in vivo or post-mortem.

Goto has made a complete literary review of the subject of ileocæcal sarcoma, and draws the following conclusions: It is more common in the males after fifty years of age. From the pathological standpoint it is expressed as circumscribed tumors which frequently lead to stenosis. Symptomatically there is rapid emaciation, a tumor which is readily movable on palpation, and which grows very rapidly, with signs of stenosis. It is very difficult to make a diagnosis between sarcoma and carcinoma. Prognostically, sarcoma of this region is much more favorable than in other localities. Farr⁷ reports a successful case of resection of cæcum for sarcoma involving the ascending colon, and says he could find but 3 cases involving the cæcum and ascending colon reported up to the time of the report of his case. Hitzrot⁸ reports a successful resection of the jejunum for three tumor masses near the portion of the small intestine occurring in that portion of the jejunum about 20 inches from the ligament of Trietz. Gerster⁹ reports two cases of sarcoma of the intestinal tract. One involving the large portion of the duodenum about as large as a small spanish olive. The patient died from severe hemorrhages. Second case, the sarcoma as big as a hen's egg, occupying the jejunum 7 or 8 inches from the ligament of Trietz. It had caused an intussusception involving 5 or 6 inches of the gut. Intestine was resected, the patient made a good recovery. Pathological diagnosis was lymphosarcoma.

CASE I.—J. B., American, aged sixty-one, male, laborer, addicted to daily eating of white sand, with history of rapid emaciation and beginning cachexia, presented on examination a firm mass in left umbilical region.

Operation March 22, 1915, revealed tumor of ileum, the size of egg, encroaching upon the mesentery with much thickening of mesenteric fold and induration of a large section of ileum.

Three feet of the ileum with corresponding mesentery were resected, followed by an entero-colostomy: the proximal end of the ileum was anastomosed to the ascending colon. Drainage was instituted. Case made an uneventful recovery. Discharged from hospital April 17, 1915.

Pathological section by Doctor Hindman shows lymphosarcoma of ileum.

Death ensued ten months later from acute hemorrhage of bowel associated with severe pain and tenesmus.

CASE II.—Mrs. H., German, aged sixty-seven, usual weight 180, strong and muscular, present weight 140, weak, cachectic in appearance, gave the following history: Father died of apoplexy at 63; mother, 83, liver trouble; one brother 48 died of cancer of rectum.

Personal History.—Had measles. Menstruated at thirteen, normal. Married at twenty. Six pregnancies, normal deliveries, nursed each one to one and one-half years. Appetite always good, a mixed eater, food always cooked but great fondness for raw apples; never constipated. Has had bad teeth with pyorrhœa for years. Had rheumatic fever often for past fifteen years. Thirty-five years ago had gastric disturbance with vomiting, and repeated often to menopause at fifty-one. Four years ago gastric attack with jaundice.

Present illness began October 20, 1918. Some pain in right abdominal region and shortly after noticed a lump. Never noticed blood or mucus in stools. Physical examination shows emaciation with cachexia, pyorrhœa, myocarditis with intermissions of pulse. Blood-pressure, S 155, D 85. Abdominal palpation revealed a tumor, freely movable, not sensitive to pressure in upper right quadrant. The balance of organs were normal. Examination of stools demonstrated occult blood and bloody mucus. Urine negative, excess of indican.

X-ray shows stomach fills normally, is in good position and shows normal peristalsis. A large mass can be felt, apparently in the colon just above the cæcum.

Six-hour Finding.—Stomach empty, bismuth in colon to splenic flexure, filling defect just above cæcum. A slight amount of the barium meal still in the terminal ileum.

Ten-hour Finding.—Ileum empty, barium meal in colon to splenic flexure.

Twenty-six-hour Finding.—Bowel nearly empty, traces only of the barium meal left. A trace in the mass above the cæcum.

PRIMARY LYMPHOSARCOMA OF THE INTESTINES

Under gas-oxygen anaesthesia operation December 12, 1918, revealed a non-adherent tumor of ascending colon about two inches below the hepatic flexure the size of a small orange. A contracted gall-bladder filled with stones was also present. Owing to the severity of symptoms a two-step operation was deemed advisable. The ascending colon was excluded and the ileum anastomosed to the left transverse colon. She left the hospital after the fourth week.

There was an interim of three months before her second operation, an interim of decided improvement and a later recurrence of pain and ill feeling that forced her to seek further surgical interference. On opening the abdomen, the tumor had penetrated the wall of the colon and through the transversalis and oblique muscles, the colon firmly adherent to abdominal wall and under surface of liver. The affected portions were removed *en masse*, as well as perirenal fat, superficial lymphatics of kidney, gall-bladder and mesenteric glands. Bleeding somewhat profuse. The omentum was utilized in the exclusion of the large open abdominal space. Both the gall-bladder and kidney area were drained, tubes removed on the seventh and fourteenth day, respectively. Left hospital fourth week, wounds closed. Up to present time she reports herself well.

Several sections of the tumor made by Doctor Hindman demonstrate a lymphosarcoma of the colon.

The post-operative mortality of these cases is high, death usually ensues from peritonitis.

Both of the reported cases were drained and convalescence from the operation was uneventful.

From the review of fatal case reports and in the light of my experience, I feel constrained to advocate drainage in all.

Stenosis of the bowel was not present in first case. In case II X-ray findings and first operation showed a patent lumen of colon, but with the lapse of time occlusion developed to practically complete obstruction.

The post-operative prognosis of these cases varies. From a perusal of case reports death may result from rapid recurrence or the patient is living and well from periods of one to five years. The fatality of lymphosarcomas in other regions of the body and their tendency to recur are amenable to radiation. If radium exerts a beneficent influence in such regions, it should be used as a post-operative agent in all lymphosarcomas involving the intestinal tract. Bloodgood¹⁰ says: "The one lesion of which, as far as I know, surgery has never accomplished a cure, is lymphosarcoma of the lymph-glands, and apparently radium has done so. Therefore, as soon as this diagnosis is suggested and established, radiation should be given, and continued at intervals, to the entire lymphatic-gland system."

Case II, after short circuiting the colon, leads one to wonder why in such a brief time there was such a rapidity of growth and infiltration of

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surrounding structures with extensive peritoneal adhesions. Do the enzymes have a restraining influence on these growths, or do the enzymes misdirected in their function, or the absence of them in the functionless loop, accelerate the growths? These are questions that are open for investigation either to refute or confirm.

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"THE GUILLOTINE AMPUTATION"*

By THOMAS G. ORR, M.D.

OF KANSAS CITY

CAPTAIN, MEDICAL CORPS, U. S. ARMY

THE term "guillotine" as applied to amputations is perhaps not as suitable or as descriptive of the operation that is really done, as the term "flapless operation," but priority counts for much in medicine and surgery and the word will, no doubt, continue in use.

The guillotine amputation is, as far as modern surgery is concerned, a product of the World War. The method was used and advocated by Fitzmaurice-Kelly in 1915 as a life-saving measure for certain types of severe infections following war wounds. He recommended its use in cases of gas gangrene, compound comminuted fractures in which amputation was indicated and in certain cases with multiple wounds. One statement of his in regard to the operation is, "that it seems advisable to make it clear that the method is not a routine one, but is designed to meet new difficulties and dangers, and is used in special cases for quite definite reasons." Its advantages are enumerated by him as life-saving, saving of length of limb, lessening the risk of hemorrhage, arresting the spread of infection, and as being possible when no other method is possible. To these may be added the advantage of shortening the time of the operation and anæsthetic, thereby reducing shock. It is to be emphasized that the operation is done as a life-saving procedure and carries with it the probability of a future operation.

The technic of the guillotine operation as described by Fitzmaurice-Kelly was not a true guillotine in the sense that the extremity was cut squarely off as might have been done with the historic guillotine blade. The skin was divided in a circular fashion, permitted to retract, as it will always do to a certain extent, and the muscles and bone were divided in the plane of the retracted skin. So many modifications of this procedure have been used, depending usually upon the available tissue, that it is probably wiser to include under the term guillotine all flapless amputations.

It has been urged by some that flap operations should be done instead of the guillotine and drainage facilitated by packing the flaps apart or stitching them back until infection subsides. In order to make flaps above the diseased part it is necessary to remove more bone than with the guillotine technic. By making flaps the drainage is apt to be hampered, the flaps may slough and if they do not slough may become distorted and produce a misshapen and undesirable stump requiring further operation.

*From the Orthopædic Service of United States General Hospital No. 26, Fort Des Moines, Iowa.

If a guillotine is done as low on the limb as the infection will permit and at a later date a reamputation done, if necessary, the chances for sound healing and a good stump with minimum loss of bone are decidedly better than with original higher section of bone with skin flap. The so-called oblique guillotine is a splendid operation when the tissues will permit of its use. This is especially true in thigh amputations when the skin is left longer anteriorly than posteriorly. Quite a large percentage of oblique guillotine amputations of the lower thigh heal and make satisfactory stumps without further operation, and if operation is advisable a good end-covering of the stump with anterior flap can be made with little or no sacrifice of bone.

The guillotine operation will doubtless be used in selected cases in civil practice. Many surgeons can look back upon cases of serious infection of extremities in which amputation was not permitted until all hope for life had vanished without it, and when the amputation was done the patient died because of continued progress of the infection. In such cases and in the presence of gas infection the guillotine should be the operation of choice in the future.

We have been most interested in the guillotine operation as it is seen in the reconstruction hospital. Many of the overseas amputated admitted to the hospitals of this country have unhealed flapless stumps three to five months after the original operation. Of 335 patients with amputations from overseas admitted to the U. S. General Hospital No. 26, Fort Des Moines, Iowa, 199 had flapless operations; 141 of this number were unhealed upon arrival; 133 of the guillotines have been operated upon or will require operation. The accompanying table gives the statistics more in detail.

STATISTICAL TABLE OF GUILLOTINE AMPUTATIONS

Total number of overseas cases amputated	335
Total number of guillotine amputations	199 or 59 per cent.
Number of healed guillotines on admission	58 or 30 per cent.
Number of unhealed guillotines on admission	141 or 70 per cent.
Guillotined legs: Healed	7
Unhealed	31
Guillotined thighs: Healed	22
Unhealed	69
Guillotined arms: Healed	20
Unhealed	25
Guillotined forearms: Healed	9
Unhealed	13
Guillotined feet: Healed	0
Unhealed	3
Number of guillotines operated or requiring operation	133 or 66 per cent.
Legs requiring operation	30
Thighs requiring operation	76
Arms requiring operation	17
Forearms requiring operation	8
Feet requiring operation	2



FIG. 1.—Typical guillotine of upper thigh. Unhealed after six months.



FIG. 2.—Same as Fig. 1; four weeks after reamputation.



FIG. 3.—Oblique guillotine of lower third of thigh. Healed and, with trial fitting of artificial leg, again ulcerated.



FIG. 4.—Same as Fig. 3, four weeks after reamputation. Shows anterior flap covering end of bone. Patient discharged with good stump.



FIG. 5.—Healed guillotine of upper arm. Satisfactory stump. Wears artificial arm with comfort.



FIG. 6.—Healed oblique guillotine of lower third of thigh. Scar movable over bone. Discharged with satisfactory leg fittings.



FIG. 7.—Unhealed oblique guillotine of thigh with protruding bone spur.



FIG. 8.—Guillotine of leg with contracture at knee.

"THE GUILLOTINE AMPUTATION"

The operations required have been reamputations, plastics on the soft tissues, excision of bone spurs and sequestrectomies. The percentage of tender stumps due to neuromata has been very small. To date we have removed two tender bulbous nerve ends.

Reamputation is indicated in all cases where it is evident that sound healing will not take place over the protruding bone, in healed cases with large poorly nourished scars over prominent bone ends and when the site of the former amputation is undesirable for fitting.

Plastic operations are done for deep adherent irregular scars that are tender, prone to ulcerate or produce an eczematous condition of the surrounding skin. At times it is difficult to determine whether reamputation or a plastic operation is necessary. Trial fittings aid in making a decision for or against operation. It has been learned by experience that a poor appearing stump often makes a good functional stump.

Bone spurs have been found in quite a large percentage of cases following the guillotine type of operation. Usually these spurs extend toward the granulating surface, along sinus tracts or along fascial planes between muscles. They may or may not cause trouble, depending upon their size and location. Spurs are not to be removed because of the X-ray appearance alone. When in doubt, here again artificial limb fitting is tried, which will usually decide the question of operation.

Sequestra are not infrequent in guillotined stumps. Many of them are of the ring type. The end of the sectioned bone becomes entirely separated from the shaft in the shape of an irregular ring which is usually imbedded in or completely surrounded by an involucrum. The frequency of ring sequestra may be partially due to the denuding of the end of the bone of periosteum, the aperiosteal method of Bunge.

The time of secondary operation on guillotined or infected stumps cannot be too carefully considered. To recognize this time is the deciding point between success and failure. It would be ideal to wait from three to six months after sound healing before operation, but this is hardly practicable for returned overseas soldiers in a military hospital. And it has been found that this long wait is not necessary for success. It is very necessary, however, to wait until all œdema has disappeared from the stump tissues. Early reamputation has been recommended by some writers, including Chapple² and Neve³ of England, but we are convinced that the teachings of Huggins⁴ is correct in that there should be no œdema present when secondary operation is attempted. By œdema not alone is meant the ordinary swelling that puts on pressure, but also the deep firm induration that exists around the end of the bone. When this condition exists there is certain to be more or less active infection harbored in the deep scar tissue, bone granulations and lymph spaces. When the œdema and induration of the soft parts have completely disappeared the stump may be operated upon with success regardless of the presence of unhealed areas. The length of time for tissues to reach this stage varies

greatly. Many patients have returned from France three or four months after amputation with marked œdema still present in the stump. The long duration of this condition may be accounted for partially by the frequent transferring of patients from one hospital to another that has been necessary to return them to the States. With proper treatment, including rest in bed and often warm, moist, antiseptic dressings, the active infection and œdema will usually disappear in from two to four weeks after the patient has reached the last hospital. The disappearance of the deep œdema is evidenced by the ability to pick up the skin and the soft tissues of the stump between the thumb and fingers. The skin is loose and can be moved about over the muscle beneath. The most important single treatment that can be used is traction. Traction promotes healing, lessens the formation of wide areas of scar tissue and conserves length of bone. As soon as a guillotine amputation is done traction should be applied to the retracting skin by means of adhesive strapping and weight and pulley, the Thomas splint or some modification thereof. This is most necessary in thigh stumps. Traction may, in some cases, be continued over a period of several weeks with marked benefit.

Aside from the danger of infections following too early operation there is a mechanical factor to be considered. In an œdematous indurated stump it is often difficult to shape and make a satisfactory closure with hard thickened skin flaps. If healing does take place under such conditions the flaps are more apt to become distorted with extensive puckered scars.

All healed cases have received forty-eight hours' preparation of the part to be operated and unhealed cases are prepared twenty-four hours prior to operation. In addition to this at the operating table the field of operation is again carefully cleansed with benzine followed by Harrington's solution and alcohol. In the unhealed cases, before the incision is made, the area to be removed is carefully painted with full strength phenol and covered with gauze to prevent wound soiling. In no case has it been necessary to remove more than two and one-half cm. of bone to effect a flap closure in the guillotined stumps. Usually the removal of one or two cm. of bone has been sufficient. It is often necessary, especially in the upper thigh guillotines, to raise anterior and posterior flaps for a distance of three to eight cm. to permit closure over the end of the bone without tension. When bone spurs are present they are usually removed when reamputating but needless operating is not done and good bone never sacrificed to remove small and what seem to be harmless spurs. It may be of some interest to note that the femoral artery has never been opened in reamputations upon thigh stumps. Bleeding is always very free in these healing or healed stumps, but the larger vessels are seldom encountered.

In sequestrectomies and the more serious types of guillotined thigh stumps the Carrel-Dakin treatment is used and has given good results.

"THE GUILLOTINE AMPUTATION"

In a great majority of the cases sound healing will take place with only rubber-tube drainage. In all cases where blood or serum is apt to collect beneath flaps drainage is used.

Judging from knowledge we have received we have nothing but praise for the work of the surgeons overseas in handling the amputated. For the most part patients have received good and proper amputations and postamputation treatment. There are, without question, cases that would have healed with flap operations and primary or secondary suture when the guillotine was used, but from the histories we are able to obtain such cases are very much in the minority, and at the time the amputations were done were probably doubtful or potentially infected cases.

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TRANSACTIONS
OF THE
NEW YORK SURGICAL SOCIETY

Stated Meeting, held February 12, 1919

The President, DR. CHARLES H. PECK, in the Chair

CARCINOMA OF THE STOMACH—POLYA-BALFOUR OPERATION

DR. JOHN F. ERDMANN presented five cases of resection of the stomach for carcinoma, by the Polya-Balfour method; these were five out of thirteen which he had done in the past five months. He showed X-rays of the cases and an X-ray of one of the post-operative patients, showing the current of barium very beautifully. The youngest of these patients was twenty-seven and the oldest was sixty-nine.

DR. CHARLES N. DOWD presented a case similar to the ones presented by Doctor Erdmann. A year ago the patient came to the hospital; she had been suffering for many months, was continually vomiting, emaciated and only weighed one hundred and ten pounds, a loss of thirty-seven pounds. On palpation a mass was felt and the Polya operation was done. No difficulty was experienced in bringing the jejunum through the transverse mesocolon, and one-half of the stomach was resected. She made a quick recovery and at the present time is well and weighs one hundred and twenty-seven pounds.

DOCTOR DOWD asked if there was any information as to the condition of the proximal loop in the anterior Polya procedure.

DR. HERMANN FISCHER said that some time ago he had the opportunity to present one of his patients upon whom this operation had been performed. He was very much pleased with the result of it. All five patients upon whom he operated stood the operation very well, although three of them had carcinoma and were not altogether good risks. The post-operative recovery was comparatively quick. The X-ray examination after the operation showed in all patients a slight delay in the evacuation of the stomach contents, probably due to a muscular weakness, caused by the operative trauma. The patients had, however, no subjective symptoms. In performing the operation he has found it practical to divide the duodenum first, after having freed the stomach from its attachments. The stomach is then pulled out of the abdomen until sufficiently exposed to attach the loop of small intestine (jejunum) at the place where the anastomosis is to take place. Two guide sutures are placed at the small and large curvature and the tumor resected. This obviates the necessity of using clamps.

RECURRENT ULCER OF THE STOMACH

DR. WILLY MEYER stated that last fall he had an opportunity to do a Polya operation and was struck by the apparent ease and beauty of the whole procedure as modified by Balfour and was delighted by the result. The patient made a good recovery and is well to-day. At first she mashed everything she ate, but lately has been partaking of food with her family. There is one point in these cases with regard to the slipping of the stomach-stump from the grasp of the clamp at the upper angle, if the resection had to be done well towards the cardia, close to the costal arch. Such slipping will not make a very great deal of trouble because the area is well padded with gauze below. Still, it is most unwelcome. To avoid slipping one will best apply an additional rectangular clamp at the lesser curvature, nearer to the cardia, or stitch and tie the stomach at the upper angle on to the clamp.

DR. GEORGE WOOLSEY said of Doctor Dowd's question in regard to what happens to the long loop, that he was going to ask Doctor Erdmann what, in his opinion, is the advantage of the Balfour modification, especially in the first case, where the carcinoma was well toward the pyloric end. He could see the advantage of it where one has to resect over one-half of the stomach, for there one has to pull up quite a loop of the jejunum through the transverse mesocolon, and he has often wondered whether there was any chance of strangulation in that passage through the transverse mesocolon. The convalescence is remarkably smooth after the Polya-Reichel operation; much smoother than after simple gastro-enterostomy.

DOCTOR ERDMANN in closing said he had not seen any untoward results from the Polya-Balfour operation, but on reading the Balfour article, one will note that the writer insists very distinctly that the proximal end is attached to the lesser curvature and the distal end attached to the greater curvature. He does not state why.

DOCTOR ERDMANN stated that he had done somewhere in the neighborhood of eighty Polya operations in the last four years and had had two deaths by the loop going up through the mesentery (this was evident by X-ray) and becoming strangulated because of the early absorption of the suture material used attaching the stomach to the hole in the transverse mesocolon. Since that accident he has used the Pagenstecher suture.

In regard to the modification question of Doctor Woolsey he said that he had never had any more trouble in doing the original Polya than with the Polya-Balfour.

RECURRENT ULCER OF THE STOMACH

DR. JOHN ROGERS presented a patient, aged twenty-six, who gave a long history of epigastric distress beginning in 1915. In August, 1917, she was operated upon in the Polyclinic Hospital for gastric ulcer and an hour-glass contraction was found. The surgeon who performed the operation told him that he excised an ulcer about one inch in diameter

from the centre of the lesser curvature, after separating from the ulcer a strip of the great omentum which indented the greater curvature, the stomach resumed its normal outline, and he therefore only closed the space left after the excision of the ulcer.

The recovery was uneventful, but the patient says the epigastric pain and distress were only partially relieved. After resuming work the symptoms increased and were accompanied by recurring attacks of vomiting.

When she came to Bellevue in January, 1919, the gastric analysis showed a total acidity of 20, and the radiograph a typical hour-glass contraction at the junction of the upper and middle thirds of the stomach. The test meal had apparently been recovered only from the upper pouch.

On January 15, 1919, the abdomen was opened through the outer border of the upper end of the left rectus. The stricture under the left costal arch could only be partially drawn into the wound. A band from the great omentum was separated from the ulcer in the concavity of the indentation on the lesser curvature, and this allowed the indentation on the greater curvature to disappear. The borders of the indentation on the lesser curvature with the ulcer at the bottom were then resected, leaving intact about one inch of the anterior and posterior surfaces of the stomach at the greater curvature. In this area along the greater curvature there was no scar tissue. After the removal of this V-shaped segment of the stomach, the borders of the wound were sutured so as to restore almost perfectly the normal contour and the abdomen was closed. In the subsequent twenty-four hours the condition was precarious, as the operation on account of the inaccessibility of the ulcer and stricture was long and difficult, but the recovery was then uneventful. A radiograph taken a month later showed that the hour-glass contraction had already partially reformed, and the patient is presented to show the apparent necessity of complete transverse resection in these cases, even though at the time of operation a part of the "hour-glass" contraction is free from cicatricial tissue. At present, however, this patient has no subjective symptoms.

CASES ILLUSTRATING THE CONSERVATIVE TREATMENT OF SARCOMA OF THE LONG BONES

DR. WILLIAM B. COLEY presented the following series of patients:

CASE I.—*Recurrent inoperable fibrosarcoma of the nasopharynx and soft palate; apparent entire disappearance under the mixed toxins of erysipelas and bacillus prodigiosus and radium.* Male, aged thirty years, who was referred to him on August 30, 1918, by Dr. W. B. Shields, of St. Louis, with the following history:

Family History.—About five years ago a fibrous mass was removed from the left nostril. The nose remained in good shape until the spring of 1918 when the patient noticed increasing obstruction in the left nostril. He paid little attention to it until the other nostril

SARCOMA OF THE LONG BONES

began to be obstructed in the same manner. He then consulted a physician who operated on the left side and found a considerable growth extending back into the nasopharynx. It was found impossible to remove the entire tumor, which continued to increase rapidly in size after the operation.

Five weeks before he was referred to Doctor Coley, his physician, Doctor Shields, had begun the use of the mixed toxins of erysipelas and bacillus prodigiosus, injecting same systemically and into the tumor with some decrease in the size of the growth. The patient has lost twenty-five pounds in weight.

Physical examination at the time of his admission to the Memorial Hospital (September 3, 1918) showed both nostrils completely blocked by a tumor (making it impossible for the patient to get any air through either nostril), which, in addition, extended down behind the soft palate, pushing it forward into the cavity of the mouth. The most dependent portion extended down behind the uvula, causing great difficulty in talking or swallowing.

The toxins were continued in doses sufficient to produce a marked reaction, and radium treatment was started on September 24, 1918. Three small glass tubes containing a total of 10 mc. of radium emanations were imbedded in the tumor behind the palate. At this time the tumor in the soft palate had broken through the mucous membrane and a fungating mass the size of a hickory nut projected into the mouth. On September 27th, two tubes of 55 mc. radium emanations were placed in each nostril for two hours. On October 18th, three more tubes containing 13 mc. were imbedded, through a fine trocar, in the tumor behind the palate. In all the patient received 3256 mc. hours of radium emanations.

The tumor slowly but steadily decreased in size and by December, 1918, he was able to breathe through the right nostril, and two to three weeks later to get air through the left nostril as well. He also began to gain in weight, and up to the present time has more than regained the 25 pounds which he previously lost. By January 1, 1919, the tumor had practically disappeared, and at present there is apparently no tumor remaining in the soft palate and his nostrils are all clear.

Doctor Coley stated that it was impossible to say anything about the final prognosis, but that thus far the progress has been very satisfactory. A microscopical examination of the tumor, made in St. Louis, showed it to be fibrosarcoma.¹

CASE II.—Central sarcoma of the radius, clinical and X-ray diagnosis, inoperable without sacrifice of the arm. Male, thirty-nine years of age, referred to him by Dr. V. P. Gibney on April 25, 1918, with the following history: Eight years ago, bad sprain of the wrist, but apparently completely recovered. In November, 1917, or five months prior to Doctor Coley's first observation, noticed sharp pain, like the prick of a needle; two months later loss of power in hand; at the

¹ NOTE (May 20, 1919).—Shortly after leaving hospital tumor recurred and grew rapidly. It is again decreasing under treatment, but recovery is very doubtful.

same time he noticed an enlargement of the lower portion of the left wrist which increased rapidly.

Physical examination showed enlargement of the lower portion of the left forearm, extending down to the wrist. The tumor was apparently primary in the radius, involving the lower three inches. The whole wrist was markedly enlarged, the circumference being $2\frac{1}{2}$ inches greater than on the normal side, with some thickening of the ulna as well. There was a pathologic fracture of the radius and almost complete fracture of the ulna. The skin was normal and not adherent; the tumor was soft, semi-fluctuating in consistency. The clinical diagnosis of sarcoma was made and confirmed by X-ray examination. The X-ray picture showed complete destruction of the radius for more than 2 inches; the tumor had apparently broken through the outer shell of bone and extended outward, involving the soft parts which were pushed to one side. On the left side the tumor extended beyond the ulna which was apparently involved. The X-ray picture did not fully show the damage to the ulna, but the clinical examination showed almost complete pathologic fracture.

Amputation had been advised and the patient was willing to sacrifice the arm, if necessary. He was admitted to the Hospital for Ruptured and Crippled on April 25, 1918, and put upon the systemic injections of the mixed toxins of erysipelas and bacillus prodigiosus. Only one injection was made directly into the tumor, $\frac{1}{8}$ minim. This was followed by a very severe reaction, a temperature of 104° , nausea and vomiting and marked herpes of the lip. The systemic injections did not produce any marked chill or severe reaction until the dose had been increased up to 6 mm., finally increased to 12 minims. At the time the toxins were begun the measurement over the most protuberant part of the tumor, 2 inches above the lower end of the radius, was $10\frac{1}{2}$ inches; normal side, 8 inches. Doctor Coley stated that he had first intended to use both radium and the toxins in the hope of saving the limb. During the first two to three weeks of toxin treatment there was very little improvement and in the early part of June, when Doctor Coley was out of town for a week, Dr. J. P. Hoguet, who was left in charge of this case, came very near amputating the arm, believing that there was little or no hope of saving it by conservative treatment. The patient was quite willing to submit to the operation.

When on Doctor Coley's return on June 10, there seemed to be appreciable improvement, he decided not to use any radium and the injections of toxins were kept up systemically, every other day, in doses sufficient to produce a temperature reaction of 102° to 104° . By the end of June the swelling had nearly subsided and by the end of July it had entirely disappeared. The arm had been kept in splints during the early part of the treatment and later, after the tumor had disappeared, was kept in plaster-Paris with the hand in an abducted position, to avoid deformity while the new bone was forming. The patient left the hospital in August, and the treat-

ment was kept up 2 or 3 times a week until the 1st of January, 1919. Frequent X-ray pictures were taken of the wrist, and these show gradual increase in new bone taking the place of the 3 inches of radius and ulna which had been completely destroyed. The patient is still wearing a short palmar splint; the new bone which has replaced the lower end of the radius is not entirely solid yet, but Doctor Coley believed that it would soon be completely restored and the arm would be quite as useful as ever. He felt some confidence in his prognosis for the reason that in two similar cases in which the tumor had disappeared under the toxins without other treatment—the diagnosis of sarcoma in both confirmed by microscopical examination—there had been complete restoration of the function of the respective limb; one of these patients was now well more than ten years and another was well three years when last observed.²

CASE III.—*Very large inoperable sarcoma of the upper portion of the femur, following a recent fracture; disappearance under combined toxins and radium treatment.* Male, thirty-six years of age, who had been entirely well up to January, 1917, when he slipped on the ice, causing a fracture of the left femur, a little below the trochanter. He was taken to St. Vincent's Hospital in Bridgeport, Conn., where he was treated by Col. Geo. W. Hawley. Doctor Coley stated that X-ray pictures had been taken at the time, but owing to Colonel Hawley's having been engaged in military service, he has been unable to see the pictures as yet, but he had seen the hospital report of the X-rays and had it confirmed personally by Colonel Hawley. The hospital report mentioned nothing more than an oblique fracture below the trochanter. If there had been a pathologic fracture due to a tumor already present, it probably would have been discovered at the time of the first X-ray picture. The patient did well for nine weeks, at the end of which time a swelling appeared at the site of the fracture, and steadily increased in size. He remained at St. Vincent's Hospital for twenty-seven weeks. The tumor steadily increased in size, and on October 3d the patient was admitted to the German Hospital, New York City, where he came under the care of Dr. Hermann Fischer. On October 20, Doctor Fischer referred the patient, as an inoperable case, to Doctor Coley's service at the Memorial Hospital. He was examined at a conference of the hospital staff, and all regarded the case as a sarcoma of the femur entirely beyond hip-joint amputation. At this time the middle upper portion of the left thigh measured 68½ cm. and the right thigh, 51 cm. Longitudinally the tumor extended for a distance of 17 cm. The mixed toxins were begun on October 30, 1917, and continued 3 or 4 times a week, alternating the systemic with local injections, and producing severe reactions. On November 5 and 6 he was treated with very large doses of radium, by means of a pack, applied at 10 cm. distance, and remaining for a total of sixty-one hours. He received a total of 40,000 mc. hour at one treatment. An

² May 2, 1919. The wrist is practically normal and patient working without any splint or support.

X-ray picture taken at the time of his admission to the Memorial Hospital showed complete destruction of the bone, involving the neck of the trochanter and upper five inches of the shaft. An X-ray picture of the chest showed "chronic diffused bronchitis both apices (cloudy plates) suggestive of tuberculosis—probably metastases from the tumor in the femur."

By December 10 there had been a decrease of 4 cm. in the circumference of the thigh. The radium was again applied on December 25, 1917. Examination on April 8, 1918, showed a still further decrease in the circumference of the thigh. The toxins were kept up without further radium treatment. On June 23d the patient was sent home to Bridgeport, Conn., to remain there during the hot weather and return in the fall. At that time his general health was good; the tumor had decreased in circumference from 68 to 60 cm., with a corresponding decrease in the vertical dimension; there was still marked mobility at the site of the fracture. The leg was put in a Thomas splint. He received no treatment during the summer.

On October 8, 1918, the patient was readmitted to the hospital, at which time his general health was good, and clinical examination showed apparently complete disappearance of the tumor. The circumference of the left leg, 33 inches, and the right, 38 $\frac{1}{4}$ inches, showing a shortening of 5 $\frac{1}{4}$ inches. The circumference five inches below the trochanter, left side, 21 inches, and the right, 23 $\frac{3}{4}$ inches. Circumference five inches above upper border of patella, left side, 19 $\frac{1}{2}$ inches; right, 20 inches. The patient had had no treatment since leaving the hospital in June. X-ray pictures taken at the time of his readmission showed apparently no tumor tissue left. The proximal portion of the femur at the site of the pathologic fracture had been drawn upwards to the region of the trochanter, and there was an attempt at union due to formation of new bone. X-ray examination of the chest was negative.

At the present time the patient is still wearing the Thomas splint adjusted by Doctor Gibney. He is in excellent health and his weight is normal.³

CASES IV AND V.—Doctor Coley also again showed two cases of extensive sarcoma of the long bones, one of the femur, involving the knee-joint, the other of the upper end of the tibia, in both of which cases amputation had been advised, but which had recovered, one under the toxins alone, the other under combined toxin and radium treatment. Both of these cases were shown before the New York Surgical Society, November 22, 1916. At that time they were using crutches. The patients are now in good health and walking without crutch or cane, one four and one-half years after treatment, the other three and one-half years after treatment. These cases were reported in full in the Transactions of the New York Surgical Society of November 22, 1916 (ANNALS OF SURGERY, March, 1917, p. 370) and the report contains a full record of the cases together with photographs and microphotographs.

³ NOTE (May 10, 1919).—Union is nearly complete and patient is getting about with a Thomas splint and high shoe. X-ray shows no trace of tumor.

SARCOMA OF THE LONG BONES

The first case was a central sarcoma of the lower end of the femur with extensive involvement of the knee-joint, in which Doctor Coley and Dr. V. P. Gibney both advised amputation, but the patient refused. This patient recovered entirely under no other treatment than the toxins, administered systemically and kept up for nearly a year. She is still wearing a brace fitted by Doctor Gibney and has about $2\frac{1}{2}$ inches shortening, due to the fact that one condyle was completely destroyed and the other was pushed to the outer side, so that the femur now rests upon the upper end of the tibia with a stiff joint.

The second case was a mixed-celled (giant and spindle) sarcoma of the upper end of the tibia with (some) involvement of the fibula. In this case Doctor Whitman had strongly advised amputation, believing that the leg would be of no use even if the disease was cured, but the patient refused. The tumor, which involved 5 inches of the upper end of the tibia and a portion of the fibula, was thoroughly curetted out under ether, the wound packed and the limb put in a plaster splint, and the toxin treatment begun. Four months later the toxins were left off for a month. The disease rapidly recurred. A second curetting was performed with immediate recurrence and the patient then put back on the toxins, this time combined with radium on two occasions; first 150 mc. radium emanations were applied and later 240 mc. for fourteen hours. The toxins were continued six months longer. The patient remains well at the present time, three and one-half years later. There has been reformation of the bone and she now has a very useful limb, walking without crutch or cane.

DR. GEORGE WOOLSEY said that cases of sarcoma cured without amputation are bright spots in surgery. Fortunately, there is a class of tumor, the central large giant-celled sarcoma of the long bones, that we can treat in this way. He related an experience he had three years ago where he curetted the lower end of the femur and had X-ray treatment applied at intervals for the next year. The patient is well to-day. In an earlier case local recurrence within a year had led to amputation. It is possible that repetition of the curetting might have been effective.

DR. WILLY MEYER mentioned a case where he had done the radical excision of the breast in a woman believed to have Paget's disease. She had been treated with chemical escharotics (the breast and nipple having been destroyed). Being the mother of five children, she, at first, never allowed radical work. About half a year after the operation she developed signs of a typical "cancer en cuirasse." He now referred the patient to the General Memorial Hospital for treatment with radium and X-ray, and to-day the disseminated cancer nodules have disappeared. He did not know whether there is any internal carcinoma developing, but she does not cough and there is no sign of recurrence. The radium and X-ray have been found to favorably influence this dreaded occurrence. Now she has developed a cancer of the other breast and will be operated on in a few days.

ABDOMINAL LIPOMATOSIS

DR. F. S. MATTHEWS presented a boy seven years of age who was admitted with a history of progressive enlargement of the abdomen. At the age of one year, he had been operated on, a large incision made, and said to have an inoperable tumor. Examination showed an emaciated boy with enormous abdomen, flat on percussion, feeling soft rather than tense, and on deep pressure giving the impression of masses in the abdomen. There was no fluid wave. Incision in right rectus muscle encountered large lobules of fat. These were removed in quantities until eighteen pounds of fat had been removed. After operation, he weighed forty-three pounds. The fat lay mainly between abdominal wall and peritoneum, the viscera being pressed against the spine. It invaded the space of Retzius and extended up around the left kidney. The mesentery was nowhere invaded except at the left side of the transverse mesocolon. The peritoneum was torn anteriorly and sutured. No blood-vessels were ligated. Practically all the fat was removed from the abdomen. He made a good recovery and is now a well-nourished instead of an emaciated child.

PYELO-NEPHROLITHOTOMY—SECONDARY HEMORRHAGE. AVOIDANCE OF NEPHRECTOMY BY REPEATED SUBCUTANEOUS INJECTIONS OF HUMAN BLOOD SERUM

DR. WILLY MEYER presented a patient in whom he had done pyelonephrolithotomy for stones in the pelvis and parenchyma of the right kidney. The section cut of the upper two-thirds had revealed a small focus with a nest of quite a number of stones.

The kidney was sutured with chromicized gut through and through in the usual way. Five days after the operation a pronounced hemorrhage set in, which was followed by two others. Inasmuch as the kidney had proved to be healthy, nephrectomy was not favored, and an attempt was made to combat the hemorrhage by repeated injections of human blood serum as follows: first 500 c.c. were given within three days; three days later 100 c.c. and again after ten days 375 c.c. within two successive days. This decreased the coagulation time to four minutes. With careful after-treatment the hemorrhage did not return and the patient was shown in perfect health.

CHRONIC EMPYEMA

✓ DR. WILLY MEYER presented a young girl who had been under his care for the last five years and had been presented before the Society a few years ago, when not yet cured. By persistent treatment which consisted in gradual exposure of the deep cavity which ran parallel to the spine, the deep groove had at last been brought to cicatrization. There was still a small bronchial fistula beneath the inner border of the scapula, which it is intended to keep open for some time.

The patient, who had had empyema, following pneumonia, ever since

DISINFECTION OF WOUNDS WITH CHINOSOL AND SALT

she was four years of age, and had been operated upon four times before she came under Doctor Meyer's care, without the cavity being closed, is now at last to be considered cured, after twenty-two years of suppuration.

DR. NATHAN W. GREEN said he had seen quite a number of similar cases, worked on them and followed them up; and it appeared to him most important that these operations should be done in stages. There frequently is a spontaneous diminution in the size of the cavity up to a certain point provided drainage is ample. It is well not to operate on these cases until they have been given some length of time for drainage. Then the cavity is much smaller and not quite such a wide resection of ribs will have to be done.

EXTRAPLEURAL THORACOPLASTY FOR ADVANCED PULMONARY TUBERCULOSIS

DR. WILLY MEYER presented a man, thirty-one years of age, who had been suffering from left-sided pulmonary tuberculosis for the last four years. When he came to New York in the early part of November, 1918, he suffered from frequent sudden attacks of high fever, expectoration, rapid pulse and great weakness. There was multiple cavity formation in both lobes, particularly the upper. Artificial pneumothorax proved impossible on account of extensive adhesions between the two lobes of the pleura. This was the reason that he was sent from Saranac Lake to New York for operation. It was decided to do thoracoplasty in two stages. On November 18 the tenth to sixth ribs were resected (6 to 7½ inches) under regional and local anæsthesia with ½ per cent. novocaine. This was nicely feasible. On December 10, the second stage was added with resection of the fifth to second ribs of from 2½ to 4½ inches.

Soon after each operation external compression with a pad and elastic straps was added. The patient made an uneventful, speedy recovery, and has been very markedly benefited by the operation. The tubercle bacilli and the fever have disappeared, the cough is much reduced and the patient's strength has increased. He now intends to return to the mountains.

THE DISINFECTION OF VITALIZED TISSUES AND THE HEALING OF WOUNDS WITH CHINOSOL AND SALT (A PRELIMINARY REPORT)

DR. WILLIAM C. LUSK read a paper with the above title, for which see page 493.

Doctor Lusk said in closing that among the merits of chinosol in combination with salt, were its stability, its ease of application, it being applied to an accessible wound by means of gauze laid in contact with the surfaces of the wound, its tendency to dry pus up, its non-irritability when applied in accordance with the technic here advocated unless possibly after prolonged use; also the facts that it appeared not to attack tendons and that it facilitated the separation of sloughs.

TRANSACTIONS
OF THE
PHILADELPHIA ACADEMY OF SURGERY

Stated Meeting held February 13, 1919

First Vice-President, DR. GEORGE G. ROSS, in the Chair

CHOLECYSTITIS FOLLOWING TYPHOID FEVER IN CHILDHOOD

DR. HARRY C. DEEVER read a paper with the above title, for which see page 534.

PYLORIC STENOSIS IN INFANCY

DR. FRANCIS O. ALLEN read a paper with the above title, for which see page 531.

DR. HENRY R. WHARTON said that in the cases of pyloric stenosis seen by him a peculiar feature is the very distinct tumor which seems to be about the size of an ordinary shellbark hickory nut and which when divided separates almost like cartilaginous tissue. Doctor Allen spoke of a case in which he failed to find a pyloric tumor but did find adhesions. A few days ago the speaker had a case at the Presbyterian Hospital which had many of the symptoms of pyloric obstruction but in which they failed to palpate a tumor. The gastric peristaltic wave was present. Operation revealed no distinct pyloric tumor, but the pyloric end of the stomach was firmly adherent in the region of the gall bladder, and was separated with some difficulty. The following day the patient was doing very well, had no vomiting up to the time of his death. At the end of the third day the pulse failed and the patient died but presented no abdominal symptoms. Attention has been called to the fact that in these cases a certain number die with marked thymus symptoms. There seems to be some association between cases of thymus gland enlargement and pyloric tumor.

DR. H. C. DEEVER said that during the last five years thirty-four cases of pyloric stenosis had been under care at the Children's Hospital of the Mary J. Drexel Home. Dr. John B. Deaver and the speaker had operated upon an equal number.

In the early cases they did a posterior gastro-enterostomy for this condition, with a mortality of 18 per cent. During the past two years they have been doing the Rammstedt operation.

The youngest patient, a child six days old, was born in the Lankenau Maternity by Cæsarean section. This child vomited continuously until the sixth day, when he was operated upon and a congenital stenosis demonstrated.

The Rammstedt operation is a very simple one, entailing little shock

PYLORIC STENOSIS IN INFANCY

and requiring not more than fifteen minutes for its performance. The amount of shock depends largely upon the condition of the child.

In their early work for this condition these children were emaciated and very poorly nourished, but during the last two years pyloric stenosis is being recognized, and hence these cases are being referred for operation much earlier than heretofore, and for this reason they are better subjects for operation.

Since they have been doing the Rammstedt operation their mortality has been 10 per cent. Hemorrhage has been a factor in this mortality. In releasing the stenosed pylorus care is necessary to guard against opening the lumen, especially at the duodenal end, where the bowel is very thin. This accident had happened to him in two instances. In both instances he promptly closed the perforation with no ill result.

He makes his incision through the anterior surface of the stenosed pylorus, making the incision parallel with the small vessels which run through the peritoneal covering; and, where there is bleeding, he transfixes the vessels and ties them. He never drops the pylorus back until he is sure that all oozing has ceased.

Regarding diagnosis, the only cases they get are those sent in by the pediatrician, the family physician never recognizing the condition. As a rule, these children are always emaciated and poor subjects for any operation. Fluoroscopic examination is a great help in confirming the diagnosis, and it also converts the skeptical.

Some writers say that the absence of bile in the vomitus is pathognomonic; he does not think this is so because the fluoroscopic examination has demonstrated in several instances the pylorus not completely obstructed. There has been absolute constipation in all their cases.

They had had two cases where the incision opened up on account of the sutures giving way. He now uses through and through silkworm sutures, not removing the sutures for ten days to two weeks.

In the thirty-four cases operated upon the diagnosis in each instance was confirmed by the operative findings.

The oldest child operated upon for pyloric stenosis was six months of age; the majority of the cases have been from six to ten weeks old.

DR. E. L. BAUER said that the diagnosis of pyloric stenosis in practically all the cases he had seen in the services of Drs. Harry C. and John B. Deaver had been rather easily made. He had seen some cases in the dispensary and some outside. If there has been any question in diagnosis the fluoroscopic examination was made and the cases studied carefully, not, however, losing any time in this study. He was not in sympathy with the attempt to feed these children as suggested by many pediatricians. Practically all such methods fail. He believed the cases to be essentially surgical and should be referred to the surgeon promptly before the chances of benefit are lessened by temporizing with medical treatment. There is always a question of doubt in diagnosis in unoper-

ated cases, particularly those that are reported as having recovered. In all the cases operated on by Doctor Deaver the pylorus was shown to be hypertrophied. Medical cases reported as recoveries are usually instances of digestive disorders in children simulating stenosis. The typical case is not likely to be overlooked. In a case at Hammonton seen in consultation by an acquaintance, the mother of the child had made the diagnosis from the text-book. If the family physician is taught that these cases should come to the operating table early the mortality records will be considerably reduced. The six-months-old child operated on by Doctor Deaver came into the Mary Drexel Home through one of the doctors on the surgical staff at the Lankenau to whom it had been referred. The child was extremely emaciated and in bad condition. The operation was attempted but with not much hope of securing good results. The child survived the operation and did well for about six weeks. It was thought that it should be kept in the hospital rather longer than the average child in order to feed it, but as with many of the cases staying long in the hospital, it picked up an infection and died of broncho-pneumonia six weeks after the operation.

DR. ALLEN, in closing, spoke of a case which he had not reported, that of a girl five years of age, who, he was convinced, had pyloric stenosis, but he was not able to prove it. There was enormous distention of the abdomen. The child was under the care of a physician during its life, being seen by him from time to time, and there was always present more or less stomach trouble. The distention was enormous. The child was having great difficulty in breathing, and though Doctor Allen could not offer any great hope of benefit, he thought he might relieve the distention by making an abdominal incision under a local anæsthetic and puncturing the bowel. He found that the distention was all in the stomach; the posterior wall of the stomach presented below the umbilicus. He put in a trocar and let out an enormous quantity of fluid and gas, but the child died before he could do anything further. He did not enlarge the incision to see what the difficulty was. The history suggested a pyloric obstruction and the distended stomach corroborated the diagnosis, but he could not say positively that a tumor of the pylorus was present.

BOOK REVIEWS

DR. JOHN RADCLIFFE. *A Sketch of his Life with an account of his Fellows and Foundations.* By J. B. Nias, M.D., M.R.C.P. Clarendon Press. Oxford. 1918. Octavo; pages 147; cloth.

This beautiful little book is a replica of the best style of Eighteenth Century typography.

To appreciate it one must review the English history of that period and particularly the reign of Queen Anne and the personality of the queen herself. One must be familiar, also, with the social conditions of England which at that time made a career, such as that of Radcliffe, possible. Nothing can contribute to the latter more than the re-reading of the charming little book "*The Gold Headed Cane.*" Indeed, upon the front cover of the present book is embossed as an ornament a cut of the gold-headed cane of Doctor Radcliffe which descended to Mead, Askew, Pitcairn, and Baillie, to finally obtain a permanent resting place in the Archives of the Royal College of Physicians of England, where it is at present.

The book opens with a brief sketch of the life of Doctor Radcliffe (1650-1714). A notable postscript to the sketch of Radcliffe is the reference to the account of the steward of the doughty doctor, from which it appears that at the height of his professional career Radcliffe used to send to his banker every ten to fourteen days a round sum of 100 pounds, presumably after meeting all his current expenditures, as in those days men banked merely for the purpose of investment.

The same book also contains the names of a number of Doctor Radcliffe's patients, with a record of the medicines prescribed for them. That he was more shrewd than learned, may be inferred from the anecdote told of him, which, though it has been told of others, perhaps had its origin with him. Radcliffe on one occasion said to Sir Thomas Millington, a man whom he could not fail to respect, that "the whole art of medicine could be put on a sheet of notepaper." Millington replied: "As far as you know, it could." Whatever the scientific attainments of Radcliffe may have been, he made a profound impression upon his period and amassed a fortune which he bequeathed to Oxford University.

Among other provisions of his will was the one by means of which he provided for two Medical Fellowships whereby two persons who were chosen out of the University at Oxford, men who had received the degree of Master of Arts "and had entered on the Physic line," should receive 600 pounds yearly for ten years, one-half of which time they were to travel in parts beyond the sea for their better improvement. These fellowships, therefore, could be awarded only every ten years, but in later years the

period of the enjoyment of the fellowships was reduced to three years and the number of fellowships were increased to three. The greater part of the present book is taken up with a chronological list of these Radcliffe fellows together with a short sketch of the life of each one of those who have occupied these positions from their foundations in 1715, down to the present time.

As one looks over this list, the impression is unavoidable that such foundations fail utterly of accomplishing anything specially noteworthy. Is it not true, that if one takes up the whole list of fellowships and prize men which one may find in the history of various foundations and societies, which were supposed to be incentives to labor and expected to be prolific of scientific attainment, is it not true that they are almost absolutely barren of permanent results of value? Scientific inquiry, scientific discovery, scientific enthusiasm, have thus far, at least, never resulted from endowments and prizes; rarely has the opportunity for study which these things present found its happy conjunction in the special mental conditions which would have made such opportunities fruitful.

The book, likewise, gives a history of the Radcliffe library, one of the ornaments of Oxford at the present time, and also of the Radcliffe Infirmary which, perhaps, has been the most useful and fruitful of the foundations which resulted from the fortune won by Dr. John Radcliffe. The book as a whole is an extremely interesting and attractive record, and will be sure to command the attention of the medical historian.

UNITED STATES NAVAL MEDICAL BULLETIN. Special Number. Report on Medical and Surgical Developments of the War. By WILLIAM SEAMAN BAINBRIDGE, Lieutenant Commander Medical Corps, United States Naval Reserve Force. Published for the information of the Medical Department of the Service at the Bureau of Medicine and Surgery, Navy Department, Washington, Government Printing Office, 1919.

This special number forms an octavo volume of 250 pages. It well illustrates the general policy of the Medical Department of the United States Government during the recent war to keep its medical officers fully informed of all phases of medical and surgical development which could be of use to them in carrying on their work for the relief of the sick and wounded of the Army and Navy. The present volume consists of a series of reports by Lieutenant Commander William Seaman Bainbridge. It is based upon observations made along the western front in England during 1917 and the first six months of 1918, under instructions of the Surgeon General of the United States Navy. To these are added data obtained while in Germany during the autumn of 1915. The experiences of the British, the French, the Belgians and the Americans in active war service are summarized. The result is a compilation of the highest interest and of great value. It is very fully illustrated by many photographs.

BOOK REVIEWS

The progressive phases presented by the war in the treatment of wounds naturally forms the first essay. There are here detailed the history of the experiences leading up to the final perfected methods of operative treatment and primary suture of war wounds. The book discusses fully the Carrel-Dakin treatment and the value of such other preparations as eusol, Dichloramin-T, magnesium sulphate, "Bipp," Flavine, crystal violet, the salt pack and hypertonic solutions, the sunlight treatment, the employment of various forms of electric current, and the uses of oxygen and ozone. The whole forms an interesting and valuable resumé of most of the attempts at wound treatment which were made during the war.

In the treatment of wounds of the joints, the method of Willems is fully discussed and illustrated. Fractures, trephined cases, and amputations, each have sections devoted to them. The Department of Plastic Surgery, especially in overcoming facial deformities, is fully treated and very abundantly illustrated.

The provisions made for the care of the wounded from the firing line to the convalescent camp form an interesting section of the book. The cuts which illustrate this portion of the book are of extreme interest and are of permanent value in preserving the record of the conditions under which relief to the wounded was carried on in this contest. Every department of work is pictorially set forth, such as the application of first aid on the field, the arrival of the wounded soldier at the first aid post, the interior of an underground dressing station, the general view of an evacuation hospital, the railroad ambulance train, the hospital ship and a transformed canal boat occupied as a ward; and finally, the more imposing base hospitals secured by transforming hotels and chateaus into places for the care of the sick, or the great pavilion assemblies, such as that constituting the great Red Cross Hospital at Netley, England.

The provisions for the re-education of the disabled then engage attention. A full statement is made of the provisions for the relief to as great a degree as possible, of those who were maimed, but who after recovery from the results of the immediate injury, remain more or less helpless and dependent upon others. One of the most notable developments of public sentiment originating in this war has been the practical character of the efforts which have been made to teach this group of survivors of the war to make the most of what remained of them after the losses which they had sustained and to so help them to become active participants in the affairs of life. What is being done along this line is set forth very fully and clearly and illustrated very largely.

Lieutenant Commander Bainbridge has certainly succeeded in bringing together a report of the highest interest and value.

BOOK REVIEWS

SIR DAVID BRUCE on Tetanus. At the session of the Research Society of the American Red Cross in France held in Paris, October 4-5, 1918, reported in the December issue of "*War Medicine*," Major General Sir David Bruce, of the British Army Medical Corps, in discussing tetanus expressed the opinion that the surgeon's knife stands in the first rank as a prophylactic. The first and most important measure in the prevention of tetanus is the thorough surgical treatment of the wound at the primary operation.

As to prophylactic injections of antitoxin, four injections of 500 units at each dose at intervals of seven days are recommended by the British Tetanus Committee. This was the original recommendation of the committee, and General Bruce says that he still remains of the opinion that the recommendation is correct, although a practice had recently become prevalent to raise the primary injection to 1500 units, while the second, third and fourth injections remained at 500 units. The prophylactic value of such repeated injections is beyond all doubt since there has sprung up experimental evidences that after about ten days the immunity conferred by an injection is to a great extent lost. While there can be no shadow of a doubt as to the effect of the prophylactic injection of antitoxin, the antitoxin as a curative agent stands upon an entirely different basis. The reporter says that in fact, there does not seem to be any statistical evidence that serum given therapeutically has any marked effect on the rate of mortality. It seems to be admitted that tetanus toxin which has been taken up and fixed by the nerves or nerve cells, is inaccessible to antitoxin. If a lethal dose has been taken up by the nerves and is traveling towards the nerve centres before the serum treatment is begun, then no amount of antitoxin will save the patient, although it may neutralize some of the free toxin in the blood and lymph and prevent its ultimately entering the nervous system and causing death, when the toxin already admitted through the motor nerves is not sufficient to do so.

As to the best route for the injection of antitetanic serum in acute general tetanus, the best method of treatment lies in the earliest possible administration of large doses of antitetanic serum by the intrathecal route. A reasonable and suitable dosage is about 16,000 units on the first and second day given intrathecally, and about 8000 units given intramuscularly.

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227-231 S. 6th Street

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